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ART. I.—*Contributions to Meteorology, being Results derived from an examination of the Observations of the United States Signal Service, and from other sources;* by ELIAS LOOMIS, Professor of Natural Philosophy in Yale College. Fifth paper. With plates I and II.

[Read before the National Academy of Sciences, Washington, April 19, 1876.]

Low temperature of December, 1872.

IN my second paper (this Jour., vol. ix, p. 8) I called attention to the unusually low temperature of the latter part of the month of December, 1872. At that time I had little information upon this subject except what could be derived from the daily weather maps, and these were unsatisfactory because the telegraphic reports had failed from a large number of the most important stations. As the observations of the Signal Service have since been published in full, the phenomena of that period can now be discussed more satisfactorily.

The temperature of December, 1872, in the United States, was not remarkably low until about the middle of the month. On the morning of December 16th the sky was overcast from Lake Michigan to Lake Ontario, and there were indications of the formation of an area of low barometer in that vicinity. At this time there was an area of high barometer central over Dakota, where the highest pressure was 30·51, and there was a cold area nearly concentric with it, the greatest depression being 25° below the mean temperature of December. By 4 P. M. an area of low barometer was developed which was central over Buffalo (bar. 29·77), accompanied by light snow and rain, and at 11 P. M. this area had reached the Atlantic coast.

On the morning of the 17th the high pressure from Dakota

had moved southeastward and was central over Cincinnati (bar. 30·44). The temperature throughout this vicinity was 15° below the mean of December. At the same time another center of high pressure appeared near the northern line of Dakota, where the barometer was 30·39, and temperature 25° below the mean. On the morning of the 18th the pressure in Dakota had risen to 30·64, with a temperature 44° below the mean. During the 18th this area of high barometer stretched out towards the southeast, and on the morning of the 19th this high pressure extended, like a ridge, from the north line of Dakota to the Atlantic coast near Cape May, where the pressure was 30·52. The greatest depression of temperature was, however, west of Lake Huron, from which region the cold area extended to the Rocky Mountains. At the same time a storm, proceeding from Texas, advanced towards the northeast, and on the morning of the 20th was central over Lake Ontario (bar. 29·43). By this storm the high pressure of the 19th was crowded towards the northeast, and the temperature rose throughout the storm area; but at the same time a new area of high barometer formed in Dakota (bar. 30·37), and the thermometer sunk 34° below the mean. During the 20th this area of high pressure moved southward, and on the morning of the 21st its center was near lat. 42°, and the pressure had increased to 30·72. The cold had now become very intense, and extended over a vast area, the greatest depression being 41° below the mean, and the area of 30° depression stretched from the Rocky Mountains to Lake Michigan, a distance of 1,500 miles. It extended southward to lat. 38°, and northward beyond the limits of the United States.

On the morning of the 22d an area of low barometer formed near the Rocky Mountains, in Wyoming (bar. 29·60), and the area of high barometer was crowded towards the southeast, being now central over Cincinnati (bar. 30·65). The cold area had increased greatly in extent, advancing southward and eastward. It was most intense at Port Stanley, on Lake Erie, where the depression was 44°; but the area of 20° depression extended from the Gulf of Mexico to Canada, and from New York city westward to long. 97°.

The storm of the 22d advanced eastward, and on the morning of the 23d was central over Lake Huron. At the same time an area of high barometer formed in Dakota and Minnesota (bar. 30·60) accompanied by a very low temperature. At La Crosse the depression was 39° below the mean, and the area of 20° depression extended from Lake Huron to the Rocky Mountains, and from lat. 37° on the south to British America on the north.

On the 23d a storm center appeared in Oregon, and on the morning of the 24th the barometer at Portland, Oregon, stood at 29·15. By this storm, the area of high pressure and of low

temperature, on the east side of the Rocky Mountains, was crowded eastward. On the morning of the 24th the highest pressure was at La Crosse 30·85, and the area of 30·40 pressure extended from long. 100° to New York, and from lat. 34° on the south to British America on the north. On Plate I. are shown the isobars for this date, for each tenth of an inch variation of pressure. The greatest depression of the thermometer was at St. Louis, 45° below the mean, and the area of 20° depression extended from the Gulf of Mexico to British America, and from long. 102° to Nova Scotia. On Plate II. are drawn curves, at intervals of 5°, showing how much the temperature at each place was above or below the mean temperature of December.

On the morning of the 25th the Oregon storm had crossed the Rocky Mountains, and had crowded the high pressure of the 24th still further eastward. The pressure was now greatest over Lake Ontario, 30·66. The cold area still stretched from Texas to Nova Scotia, the depression being 42° on Lake Ontario, and 32° at Indianola, on the Gulf of Mexico. A storm was now organized over the eastern part of the Gulf of Mexico, accompanied with heavy rain in Florida and along the Atlantic coast, changing to snow as it advanced northward.

On the morning of the 26th the center of this storm was over the Atlantic Ocean near Norfolk, Va. (bar. 29·46). At the same time another area of high barometer had formed over Minnesota (30·92) accompanied by a depression of the thermometer of 31°. On the morning of the 27th this area of high pressure remained nearly unchanged in magnitude and position, but the depression of the thermometer at several places had increased to 37°. During the 27th the high pressure diminished in amount and moved towards the southeast. On the the morning of the 28th the center of high pressure was over Tennessee (30·61) and the greatest depression of the thermometer was 29°. Another storm center had already formed in the northwest, which reached the Mississippi valley on the morning of the 29th, and now at none of the stations west of the Mississippi did the depression of the thermometer exceed 16°.

The accompanying table exhibits the observed changes of temperature from Dec. 16 to Dec. 27. Column second shows the mean temperature of December at the stations named in column first, and the succeeding columns show the difference between the mean temperature of the month and the temperature observed each day at $7^h\ 35^m$ A. M. At this hour the temperature is about 4° below the mean temperature of the day, so that the numbers given in the table should all be increased by about 4° in order to show the depression below the mean temperature at the hour of observation. The depressions mentioned in the preceding description were all copied from this table.

Observations of the Thermometer at $7^h\ 35^m$ A. M., *Dec.*16–27, 1872.

STATIONS.	Mean temp. of Dec.	Above or below the mean Temperature.											
		Dec. 16.	Dec. 17.	Dec. 18.	Dec. 19.	Dec. 20.	Dec. 21.	Dec. 22.	Dec. 23.	Dec. 24.	Dec. 25.	Dec. 26.	Dec. 27.
Portland, Or.,	39°	− 7	− 6	− 5	− 5	0	− 6	+ 7	....	+12	+ 9	+ 9	+11
San Francisco,	52	− 9	−11	−11	−11	−10	− 6	− 9	− 3	+ 3	+ 8	+ 8	+ 1
San Diego,	55	−10	− 3	−12	− 9	−10	− 9	−12	− 5	0	0	0	+ 3
Corinne,	28	−12	− 6	− 1	−20	0	−22	+ 6	+ 7	+14	+ 8	+ 7	+ 7
Virginia City,	19	− 1	− 9	−20	−24	−19	−37	+11	−36	− 7	+14	+ 3	+13
Fort Benton,	11	− 5	−12	−44	−15	−18	−41	−11	−26	−14	−19	−22	−22
Santa Fe,	31	−11	−10	−17	−16	−17	− 8	−13	− 8	−10	+ 5	− 4	+ 4
Denver,	26	−14	−20	−19	−28	−15	−31	+14	−19	− 8	+19	+ 1	− 4
Cheyenne,	26	−19	−22	− 6	−33	−27	−33	+ 6	−32	0	+11	−11	+ 8
Fort Sully,	13	−18	− 6	−24	−27	−26	−38	−11	−36	−17	−13	−28	−14
Pembina,	−4	....	−25	−25	−21	−26	−31	−12	−30	−33	−10	−25	−33
Indianola,	54	−10	−11	− 5	− 7	−16	− 7	−22	− 8	−27	−32	−22	−31
Omaha,	20	−17	−12	−11	−19	−22	−36	− 9	−34	−32	−17	−26	−27
Breckenridge,	4	−20	−20	−32	−27	−34	−36	−14	−37	−25	−16	−31	−37
Leavenworth,	26	−15	−17	−15	−15	−29	−28	−15	−30	−39	−26	−30	−30
Galveston,	56	− 8	−12	− 4	+ 7	−12	−10	−21	− 7	−21	−29	−24	−30
Shreveport,	47	− 9	−10	− 9	−10	−17	−21	−27	− 5	−25	−30	−21	−32
St. Paul,	11	−16	− 6	−16	−25	−18	−30	−11	−34	−36	−15	−12	−28
Duluth,	11	−21	−14	−26	−29	−25	−33	−29	−37	−39	−12	−18	−22
Keokuk,	26	−16	−16	− 8	−22	−26	−27	−25	−32	−43	−30	−18	−37
La Crosse,	17	−25	−13	−17	−26	−28	−40	−29	−39	−44	−21	−11	−34
Vicksburg,	49	+ 8	−11	− 5	− 7	− 9	−17	−29	− 7	−21	−27	−23	−37
Davenport,	23	−11	−15	−10	−21	−19	−27	−27	−30	−40	−23	−12	−28
St. Louis,	31	− 8	−15	− 5	−11	−21	−24	−34	−23	−45	−34	−22	−29
Memphis,	39	− 6	−12	− 5	− 9	−14	−19	−29	−13	−34	−28	−19	−29
New Orleans,	55	+ 3	0	+10	+ 2	− 2	−13	−24	− 9	+ 2	−15	−21	−32
Cairo,	35	− 9	−16	− 7	− 7	−20	−18	−37	−13	−39	−29	−24	−27
Mobile,	51	+ 5	+ 1	+ 8	+ 3	+ 1	−17	−24	− 9	− 1	−13	−13	−33
Milwaukee,	21	− 7	−14	− 9	−24	−17	−31	−33	−34	−42	−17	− 4	− 6
Chicago,	24	− 5	−15	− 1	−25	−12	−24	−34	−32	−44	−17	− 6	−20
Marquette,	18	−17	−15	−21	−27	−12	−36	−38	−28	−32	−15	− 5	− 5
Escanaba,	16	−10	−16	−18	−26	−12	−36	−24	−34	−36	−16	− 8	− 4
Nashville,	39	+ 4	− 9	0	− 6	− 5	−18	−36	−14	−31	−19	−12	−27
Montgomery,	48	+ 7	+ 4	+15	+ 2	+ 2	−16	−27	−13	− 3	− 6	−10	−28
Grand Haven,	26	+ 6	− 5	− 7	−21	−11	−19	−30	−28	−36	−26	−15	− 6
Indianapolis,	30	− 6	−19	− 5	−12	− 7	−27	−39	−23	−41	−32	−17	−22
Louisville,	35	− 3	−13	− 2	− 6	− 7	−19	−29	−12	−35	−25	−15	−28
Cincinnati,	34	− 1	−14	− 6	− 6	− 4	−17	−36	−12	−33	−31	−15	−26
Knoxville,	38	+ 2	− 3	+ 2	− 3	+ 9	−11	−34	−19	−10	−10	− 5	−24
Toledo,	28	− 9	−15	− 4	−15	− 7	−23	−43	−19	−37	−22	−20	−23
Alpena,	23	−10	−14	−11	−18	− 1	−17	−36	−25	−33	−18	−18	−10
Detroit,	25	− 7	−13	− 3	− 9	− 4	−19	....	−15	−39	−19	−18	−20
Lake City,	52	− 4	+ 3	+11	+12	+15	0	−20	−19	− 4	+ 4	− 9	−24
Punta Rassa,	65	− 3	− 2	+ 1	0	+ 3	− 4	−13	−10	− 3	+ 2	+ 1	− 6
Augusta,	46	0	+ 6	+ 6	+ 2	+ 1	− 7	−20	−23	− 7	−16	−16	−22
Key West,	70	− 3	+ 1	+ 2	+ 2	+ 4	− 4	− 5	− 3	− 2	+ 4	+ 3	− 3
Jacksonville,	54	− 7	− 1	+ 7	+ 6	+12	0	−17	−17	− 7	+ 2	−10	−22
Cleveland,	28	− 6	−11	− 2	− 5	+ 4	−16	−40	−13	−29	−24	−13	−23
Saugeen,	28	− 4	+ 9	−10	−12	− 6	−12	−27	−20	−24	−27	−24	−28
Port Stanley,	28	−12	−15	− 7	−19	− 3	−20	−44	−16	−37	−23	−22	−22
Savannah,	50	− 4	+ 9	+13	+ 3	+11	− 1	−20	−11	− 8	− 4	−18	−25
Port Dover,	28	−11	−14	− 5	−15	− 3	−21	−41	−15	−37	−25	−21	−27

Table—continued.

STATIONS.	Mean temp. of Dec.	ABOVE OR BELOW THE MEAN TEMPERATURE.											
		Dec. 16.	Dec. 17.	Dec. 18.	Dec. 19.	Dec. 20.	Dec. 21.	Dec. 22.	Dec. 23.	Dec. 24.	Dec. 25.	Dec. 26.	Dec. 27.
Charleston,	49°	— 1	+ 9	+ 2	+ 1	+11	+ 1	—16	—12	— 4	—17	—16	—18
Pittsburg,	31	— 3	—13	— 5	—10	+14	—12	—36	—11	—30	—26	— 9	—22
Toronto,	23	— 8	—10	— 2	— 9	+ 9	—13	—33	—12	—28	—24	—24	—25
Lynchburg,	36	0	+ 2	— 4	— 4	— 3	— 8	—26	—16	—18	—26	—18	—21
Buffalo,	29	— 2	— 5	— 6	— 7	+ 9	—11	—30	—12	—27	—23	—14	—17
Wilmington,	46	0	....	— 3	— 3	+11	— 2	—15	—25	— 8	—19	—12	—12
Rochester,	25	— 3	— 6	— 9	+ 1	+11	—14	—32	—12	—24	—24	—22	—21
Washington,	35	— 2	— 3	— 5	— 7	+ 2	—10	—31	— 7	—27	—27	—20	—23
Baltimore,	35	— 1	0	— 4	— 1	+ 1	— 6	—27	— 7	—24	—21	—18	—20
Oswego,	28	— 4	— 2	— 6	— 1	+ 4	— 6	—20	—14	—20	—28	—21	—23
Kingston,	21	— 1	— 3	+ 4	— 4	0	— 6	—28	— 5	—38	—42	....	—27
Norfolk,	40	— 2	+ 1	0	— 5	+18	— 7	—17	—11	—18	—19	— 4	—19
Philadelphia,	33	— 3	— 2	— 3	— 2	+ 7	— 6	—27	— 9	—22	—28	—24	—24
Cape May,	34	+ 7	— 2	+ 2	— 4	+10	— 7	—22	— 4	—23	—22	— 3	—22
New York,	32	— 2	— 1	— 1	— 2	+ 6	— 3	—18	—14	—21	—24	—24	—20
Montreal,	16	+ 1	+ 5	+ 4	— 2	+ 3	— 3	— 9	—12	—26	—32	—29	—16
Burlington,	22	— 4	+ 5	— 5	— 1	+ 3	+ 1	—14	—18	—28	—36	—34	—24
New London,	29	— 7	— 1	— 7	— 5	+ 8	— 1	—15	— 8	—20	—26	—25	—21
Mt. Washington,	6	+ 1	+ 4	+ 1	— 6	— 1	— 4	— 5	—10	—25	—25	—10	+ 2
Quebec,	14	—11	+ 5	— 4	— 9	— 2	— 6	+ 1	—21	—28	—36	—34	—18
Boston,	28	— 7	— 1	— 5	— 2	+ 6	+ 3	— 9	—19	—19	—32	—26	—17
Portland, Me.,	23	—11	— 5	— 9	+ 1	+ 6	0	— 4	—19	—21	—40	—26	—12
Halifax,	25	— 9	— 1	—17	— 1	—11	+ 9	— 6	—17	—16	—30	—23	— 2

It will be observed that at the stations on the Pacific coast the depression was at no time greater than 12°; and at Corinne the only other station west of the Rocky Mountains the greatest depression was 22°. Hence it is obvious that the extreme cold experienced in Dakota *did not come from beyond the Rocky Mountains;* certainly not from any point south of lat. 49°. During the period in question, intense cold uniformly made its first appearance on the east side of the Rocky Mountains near long. 100°. It cannot be certainly decided from the observations, in what latitude the depression of the thermometer below the mean was greatest. The greatest observed depression was not always at the most northern station, which seems to indicate that there was a source of cold independent of the transfer of air from a higher to a lower latitude. When a cold area was once formed, it exhibited remarkable persistence both as respects its form and position. In its motion southward, it followed closely the eastern slope of the Rocky Mountains, and at one time a depression of 32° extended entirely across the United States from Canada to the Gulf of Mexico at Indianola; but at Charleston and Norfolk on the Atlantic coast the greatest depression was 24°; and generally at the eastern stations the

greatest depression was less than at western stations in the same latitude.

These results appear to explain the facts mentioned in my third paper (vol. x, p. 11) showing that a great diurnal change of temperature is most common at stations near the eastern slope of the Rocky Mountains. The cold wave makes its first appearance in this region and the intensity of the cold is sensibly diminished as the wave travels eastward. An example illustrating the variable climate of the eastern slope of the Rocky Mountains occurred Dec. 24, 1872. Denver was at that time on the borders of the cold area which prevailed from the Rocky Mountains to Nova Scotia, and during the night of the 23d and 24th the thermometer fell to 2°. During the 24th, Denver began to feel the influence of the storm which was advancing from Oregon, and on that day the thermometer rose to 55°, showing a change of 53° in a day, and probably the entire change took place in less than 24 hours. Similar cases must frequently occur near the eastern slope of the Rocky Mountains, and the changes of temperature are more sudden here than they are near the Atlantic coast, because the cold which succeeds a storm is more intense than it is in the eastern portions of the United States.

It will be noticed that from Dec. 23d to Dec. 27th, the depression of temperature on the summit of Mt. Washington (elevation 6,285 feet) was generally less than at other stations in its vicinity. On the 24th, the depression on the summit was about the same as near its base; but on the 26th the depression was *twenty degrees less* than near the base, indicating that at this time the vertical thickness of the cold stratum of air did not much exceed 9,000 feet.

The fluctuations of temperature observed from Dec. 16 to Dec. 27, 1872, were similar in their general features to those occurring every winter, but they were remarkable for the long continuance of an unusually low temperature. What was the cause of this protracted period of severe cold? It can scarcely be doubted that this low temperature was, at least, in part, due to causes in operation beyond the limits of the United States. It is noticeable that during this period the barometer was unusually high, and there was a general correspondence between the curves of high pressure and of low temperature. If then we can discover the cause of the high barometer, we shall probably find the explanation of the low temperature.

In my third paper (vol. x, p. 8) I gave a table showing the number of cases in which an area of high pressure was found on different sides of an area of low pressure during a period of three years. These numbers are as follows:

On the North side,	23	cases.	On the South side,	25	cases.
" Northeast "	39	"	" Southwest "	20	"
" East "	90	"	" West "	37	"
" Southeast "	75	"	" Northwest "	19	"

It will be observed that an area of high barometer was found on the east side of an area of low barometer almost three times as frequently as on the west side; and it was found on the southeast side almost four times as frequently as on the southwest side. These numbers are to be understood as applying to the United States Weather Maps: that is, the centers of high and low pressure were restricted to a certain distance from each other, and the average distance was about 1200 miles. The prevalent direction is about 20° south of east; in other words, whenever an area of low barometer is formed in the United States, we may be tolerably sure that there exists at the same time an area of high barometer at a distance of about 1200 miles, and in a direction a little south of east.

In order to determine whether this coincidence was the result of local causes, I have examined Hoffmeyer's charts for the Atlantic Ocean and Europe and have found that an area of low barometer on the northern part of a chart, is almost invariably accompanied by an area of high barometer on the southern part of the same chart. In about three-fourths of the cases examined, the direction of the high pressure from the low is southeast, and the average distance is about 1700 miles. These results are derived from so large a number of cases that they cannot well be ascribed to accident, and seem to indicate the operation of a general law. They naturally suggest the idea that areas of high pressure are formed from the air which is expelled from areas of low pressure; and that in Europe as well as in the United States this forming process takes place chiefly on the southeast side of an area of low pressure. The comparisons which I have made also indicate that in Europe the direction of the high area from the low area is more southerly than it is in the United States, and the distance sensibly greater.

These conclusions may be tested in another way. Low barometer is generally associated with high temperature, and high barometer with low temperature. Hence we should conclude that a temperature above the mean in Iceland, would be accompanied by a temperature below the mean in Central Europe. For the purpose of comparison, I have taken the tables furnished by Prof. Dove in the Memoirs of the Berlin Academy. He has there given the mean temperature of Iceland for each month from 1823 to 1837, a period of fifteen years, and also the mean temperature of numerous stations in Europe for the same period. I selected all those months in which the

temperature at Iceland was at least one degree (Reaumur) above the mean, and placed opposite them in a table, the temperature of the corresponding months at Vienna, Berlin, Prague and numerous other stations scattered all over Europe. The number of months employed in this comparison was 50, and during this period the average temperature at Iceland was 2°·10 R. *above* the mean for the corresponding months. During the same months the temperature at Vienna was 0°·94 R. *below* the mean, showing between the two places a variation from the mean temperature amounting to 3°·04 R. or 6°·84 Fahr. If we restrict the comparison to the four months from November to February, the difference amounts to 8°·66 Fahr.

I then selected all those months in which the temperature of Vienna was at least one degree (Reaumur) *below* the mean and placed opposite to them the temperature at Iceland for the same period, and found that during the four coldest months of the year the result was of the same kind and quite as decided as in the former comparison; but during the warmer months the influence was less noticeable.

Similar differences, but not quite as great, were found to prevail throughout Austria and Germany, and the same influence in a diminished degree prevails in France, Italy and a large part of Russia. The period employed in this comparison seems to be long enough to establish a law, and I think we must conclude that when the temperature of Iceland is much *above* the mean, the temperature of Central Europe is generally depressed *below* the mean, and this influence is most decided during the colder months of the year.

The results thus obtained for the United States and for Europe suggest the idea that an area of unusually high barometer in the central portion of North America may be the result of a storm prevailing at a distance of 1500 or 2000 miles in a northwest direction. Upon referring to a map we find that the Aleutian Islands are situated in this direction, and at a distance of about 2000 miles from Oregon, and we know that in the neighborhood of these Islands the storms of winter are unusually severe and the barometer often sinks extremely low. If we had maps showing the isobaric curves from day to day in the vicinity of the Aleutian Islands, and extending to the central portions of North America, it is presumed we should find that low pressure near these Islands was generally attended by an area of high pressure in a southeast direction at a distance of 1500 or 2000 miles. The Report of the United States Signal Service for 1873 contains Meteorological observations at St. Paul's Island, lat. 57° N., long. 170° W., but I have no observations from the interior of British America suitable for comparison with them; it is, however, remarkable that in several cases

in 1872–3, when the barometer was unusually low at St. Paul, it was unusually high in Oregon or Dakota. The following is an example:

Date.	St. Paul.	Portland, Oregon.
1872, Nov. 13	29·92	30·52
" 14	29·40	30·55
" 15	29·07	30·60
" 16	29·08	30·51
" 17	29·43	30·52
" 18	28·68	30·64
" 19	28·62	30·58
" 20	28·98	30·56
" 21	29·38	30·40

During this period of nine days while the average pressure at St. Paul was 29·20, the average pressure at Portland, Oregon, was 30·50. Also from Dec. 15 to 26, 1872, the average pressure at Breckenridge, Minnesota, was 30·50, but during the same time the average pressure at St. Paul was 29·25; and Dec. 18, when the barometer at Breckenridge stood at 30·70, the barometer at St. Paul stood at 28·05.

Form of areas of maximum and minimum pressure.

In preceding articles (this Jour., vol. viii, p. 11, and vol. x, p. 9) I have shown the average form of the isobars about a storm center as derived from observations of three years. I have since made a similar comparison of observations of three years (1873–5) to determine the form of the isobars about an area of maximum pressure. The isobar selected has generally been that of 30·20; but when the observations were insufficient to show the complete form of this curve, I have taken the isobar 30·30, provided that curve was nearly complete. When both of these curves were incomplete I have taken the next highest curve whose form could be satisfactorily determined. The whole number of cases employed in these comparisons was 238. The longer axis of each of these isobars was measured, and also the axis perpendicular to the former, and the ratio of the two was determined. The average ratio of the two axes was found to be 1·91. In fifteen cases the major axis was at least three times the minor axis; and in two cases the major axis was at least four times the minor axis; the highest value being 4·6. In other words, the average form of the isobars about an area of maximum pressure is an oval whose major axis is nearly double the minor axis; and in six per cent of the cases the major axis is three times the minor axis, while in one per cent of the cases the major axis is four times the minor axis.

The average ratio of the two axes of the isobars about an area of minimum pressure was found to be 1·94; and in nearly four per cent of the cases the major axis was four times the minor axis.

The direction of the major axis of each curve was measured with a protractor, and reckoned in degrees from the north point toward the east. The following table shows the number of cases included in each interval of ten degrees. Column first shows the directions divided into intervals of ten degrees, and column second shows the number of cases occurring in each interval. In order to eliminate the influence of accidental causes, I have taken the average of each three successive numbers in column 2d, and have placed the result in column 3d. These numbers show a decided maximum corresponding to the direction N. 44° E. Column 4th shows the observations of the isobars about an area of minimum pressure as heretofore reported, and column 5th shows the averages of the same numbers taken in sets of three. These numbers also show a decided maximum corresponding to the direction N. 39° E.

The close agreement between the average form of the curves for high and low pressure, as well as in the prevalent direction of the major axis of the curve seems to indicate the operation of a constant cause. In order to determine whether this phenomenon is of a local nature, I have made a similar comparison of European observations. I took Hoffmeyer's charts from Dec., 1873, to Nov., 1874 and measured the form of the isobars about each storm center.

Position of the Major Axis of the Isobars.

DIRECTIONS.	UNITED STATES.				EUROPE.			
	High Barom.		Low Barom.		Low Barom.		High Barom.	
	Cases.	Aver.	Cases.	Aver.	Cases.	Aver.	Cases.	Aver.
0°– 10°	19	15	17	12	7	5	2	3
10 – 20	12	15	18	17	8	6	3	2
20 – 30	14	17	15	22	4	6	2	2
30 – 40	25	20	34	24	6	6	1	1
40 – 50	21	25	23	26	7	7	1	1
50 – 60	29	22	22	17	7	6	2	3
60 – 70	17	17	7	15	4	5	7	5
70 – 80	8	12	16	10	4	3	5	6
80 – 90	11	7	8	13	1	2	5	4
90 –100	3	5	14	10	1	1	2	4
100 –110	2	3	9	10	1	2	5	3
110 –120	5	4	7	6	3	2	3	4
120 –130	6	5	3	6	3	4	5	3
130 –140	5	7	7	6	5	4	1	3
140 –150	9	7	8	8	3	3	2	1
150 –160	6	8	8	8	2	2	1	1
160 –170	9	10	8	9	1	2	1	2
170 –180	14	15	10	12	3	4	3	2

Only those cases were selected which contained an isobar as low as 740 millimeters. The isobar selected for measurement was seldom the lowest isobar drawn on the maps, but the largest isobar which was complete (or nearly so) about the storm center. The number of cases employed was 70, and the average ratio of the two axes was 1·60. Column 6th in the preceding table shows the number of cases for each 10° of azimuth; and column 7th shows the averages of the same numbers taken in sets of three.

In a similar manner the isobars about areas of maximum pressure were measured. Only those cases were selected which contained an isobar as high as 775 millimeters, and frequently this was the isobar selected for measurement; but if the map showed a larger isobar which was complete, or nearly so, that was taken in preference. The number of cases employed was 51 and the average ratio of the two axes was 1·82. In the preceding table, column 8th shows the number of cases for each 10° of azimuth, and column 9th shows the averages of the same numbers taken in sets of three.

The following table presents a summary of the preceding results both for low and high pressures in the United States and Europe.

Summary of Results for Isobars.

	LOW BAROMETER.		HIGH BAROMETER.	
	United States.	Europe.	United States.	Europe.
Ratio of the two axes,	1·94	1·60	1·91	1·82
Prevalent direct. of major axis,	N. 39° E.	N. 31° E.	N. 44° E.	N. 76° E.

This table suggests some obvious reflections, but I prefer to withhold them until I have obtained a longer series of observations from Europe.

Relation of rainfall to variations of barometric pressure.

In former articles (this Jour., vol. viii, p. 4 and vol. x, p. 5) I have shown a close connection between the rain-fall and the direction and velocity of a storm's progress. I have also endeavored to determine (vol. viii, p. 11) by what indications it may be known whether the barometric pressure at the center of a storm is increasing or diminishing. Since receiving the published observations of the Signal Service for eleven months (Sept., 1872 to July, 1873) I have resumed this discussion and have discovered a decided connection between the amount of rain-fall and the pressure at the center of the storm. For the purpose of comparison, storms were divided into three classes; one class including those cases in which the barometric depression at the center of the storm was the same on two successive

days, or the change was less than 0·05 inch. A second class included those cases in which the pressure at the center *decreased* to the extent of at least 0·05 inch; and a third class included those cases in which the pressure *increased* to the extent of at least 0·05 inch. The following is the result of this comparison including 194 cases for eleven months of observations.

Influence of variations of barometric pressure.

				AMOUNT OF RAIN-FALL.		
	No. of cases.	Barom. at centre.	Variation in 24 hours.	Within isobar 29·90.	Within isobar 29·80.	Greatest fall.
Pressure increasing,	45	29·58	+·100	·069	·078	0·65
" stationary,	81	29·56	—·005	·120	·149	0·86
" decreasing,	68	29·48	—·128	·134	·159	1·02

Column 2d shows the number of cases of each of the three classes of storms investigated; column 3d shows the average pressure at the center of the storms under investigation; column 4th shows the average change of pressure at the center of the storm in twenty-four hours, + increasing, − diminishing; column 5th shows the average rain-fall for eight hours at all the stations included within the isobar 29·90; column 6th shows the average rain-fall at the stations within the isobar 29·80; and column 7th shows the average obtained by taking the greatest rain-fall reported for each storm at any of the stations. This greatest rain-fall generally occurred near the center of the storm-area.

These results clearly indicate that the amount of rain-fall is least when the pressure at the center of the storm is increasing, or the storm is diminishing in intensity; and the amount of rainfall is greatest when the pressure at the center of the storm is decreasing, or the storm is increasing in intensity; and we arrive at the same conclusions whether we take the average rain-fall at all the stations within the isobar 29·90; or confine ourselves to the stations within the isobar 29·80; or take simply the single station which reports the greatest rain-fall. This effect is most decided during the colder months of the year.

Stationary storms near the coast of Newfoundland.

In a former article (vol. xi, p. 17) I have noticed the fact that storms sometimes remain almost stationary for several days near Nova Scotia or Newfoundland. This phenomenon I ascribe to an unusual precipitation of vapor in that vicinity. The vapor is furnished by the warm water of the Gulf Stream, and the high-lands near the coast afford facilities for its precipitation. We should therefore expect to find the average rain-fall in this vicinity to be unusually great. That such is the fact is shown by the following table which gives the annual

rain-fall at various stations along that part of the coast. For this table I am indebted to Mr. G. T. Kingston, Superintendent of the Meteorological Service of Canada.

Annual Rain-fall in Nova Scotia and its vicinity.

STATIONS.	Latitude.	Longitude.	Average rain-fall. Inches.	No. of years.
St. Johns,	47° 33′	52° 40′	55·86	4
Harbor Grace,	47 42	53 15	48·36	4
Bay St. George,	48 30	58 29	47·75	1
Glace Bay,	46 13	59 58	61·81	6
Sydney,	46 12	60 14	58·36	6
Cape North,	47 3	60 25	47·35	1
Port Hastings,	45 39	61 29	43·67	2
Guysborough,	45 23	61 36	60·40	3
Pictou,	45 42	62 40	50·58	2
Charlottetown,	46 14	63 10	41·90	3
Truro,	45 20	63 20	49·50	4
Seaforth,	44 38	63 34	47·87	2
Halifax,	44 40	63 36	51·29	11
Beaver Bank,	44 34	63 39	42·94	3
Windsor,	44 54	64 7	42·53	1
Dorchester,	45 46	64 18	48·53	4
Cape Rozier,	48 56	64 21	33·17	3
Wolfville,	45 5	64 25	41·88	8
Bass River,	46 30	65 12	38·21	5
Chatham,	47 1	65 30	44·48	2
Bathurst,	47 37	65 41	33·21	2
St. John,	45 14	66 5	54·68	9
Fredericton,	45 55	66 40	45·52	4
Quebec,	46 48	71 12	37·27	6

It will be noticed that near the southern coast of Nova Scotia and Newfoundland there is a line of stations where the annual rain-fall ranges from 50 to 60 inches, while at a distance of 200 or 300 miles from the coast, the annual rain-fall is less than 40 inches. Also if we follow along the coast of the United States as far south as Washington we find that scarcely any where does the average rain-fall exceed 45 inches. The precipitation on the south coast of Nova Scotia and Newfoundland is therefore excessive, and is sometimes sufficient to hold a storm nearly stationary for several days.

Course and velocity of storms in tropical regions.

In order to discover the causes of the movement of storm-areas, it is important to study their phenomena under the greatest possible variety of circumstances. For this purpose I have prepared a list of all the storms originating near the West India Islands, for which I have found definite paths assigned by any investigator. The principal results are exhibited in the following table. Column 1st shows the date of commencement of the storm so far as ascertained; column 2nd shows

the latitude of the storm's center when it first became violent; column 3d shows the average course of the storm while moving westward; column 4th shows the hourly velocity of progress in the preceding part of its course; column 5th shows the latitude at which the storm was moving due north; column 6th shows the average course of the storm after turning eastward until it reached the parallel of 40°; column 7th shows the hourly velocity of progress during the preceding period; column 8th shows whether rain was mentioned as accompanying the storm; column 9th indicates the name of the person by whom the phenomena of the storm were investigated; (R) stands for William Reid; (W) stands for William C. Redfield; (M) for Matthew F. Maury; (B) for Alexander Buchan; (E) for John R. Eastman; (T) for Henry Toynbee; and (S) for the U. S. Signal Service. Column 10th shows where the record of the investigation may be found.

It will be noticed that the least latitude of any storm-path here recorded is 10°; that is, over the Atlantic Ocean no storm-path has been traced within 10° of the equator. On Maury's storm chart for the North Atlantic (this Jour., vol. xi, p. 12) among 6436 observations, each observation representing a period of eight hours, four gales are reported within five degrees of the equator. Also between 5° and 10° north latitude, among 6476 observations, eight gales are reported. On Maury's chart for the eastern half of the North Pacific Ocean, among 17,854 observations, 35 gales are reported between the equator and 5° N. latitude; and between 5° and 10° N. lat. among 9352 observations, 33 gales are reported. Storms do therefore sometimes occur almost directly under the equator, but on an average only once or twice a year.

The courses of the storms mentioned in the preceding table range from 11½° south of west to 62° north of west. In two cases the course was south of west; in a third case the course was only one degree north of west, and in a fourth case the course was only 5° north of west. Tropical storms do therefore sometimes travel towards the equator; and it is probable that this direction occurs more frequently than the table would indicate, since many of the storms here recorded would never have been selected for investigation, if they had not advanced into the middle latitudes. The average course of the storms here mentioned while moving westward was west 24° north; and the average hourly velocity in this part of their course was 17·4 miles.

The average latitude of the storm's center when moving due north was 29½ degrees, and the latitudes range from 23⅛ to 34 degrees. During the three summer months the average latitude is 30°·6; in September it is 29°·7, and during the other months of the year 26°·7, indicating that the point where the course changes from west to east is more northerly in summer

than in winter. The average course of these storms while traveling eastward to the parallel of 40° was E. 38½° N. ranging from 17° to 60°. The average hourly velocity in this part of their course is 20·5 miles, which is almost exactly the average velocity of storms in the United States for the months of August and September according to the Signal Service observations.

Course of Hurricanes originating near the West India Islands.

Date of Storm.	Latitude of beginning.	Course while moving Westward	Velocity in miles per hour.	Latitude when moving North.	Course while moving Eastward.	Velocity in miles per hour.	Rainfall.	Investigator.	Where Recorded.
1780. Oct. 3.	16·5°				E. 61·5° N.		*Rain.*	R	Law of Sts., p. 273.
1780. Oct. 12.	11·8	W. 31° N.	17·8	23·3°	E. 39·5 N.	17·2	*Rain.*	R	Law of Sts., p. 273.
1804. Sept. 3.	15·7	W. 30 N.	20·4	31·2	E. 46 N.	18·1	Rain.	W	J. S., v. 20, p. 17.
1821. Sept. 1.	21·7	W. 27 N.	35·0	31·2	E. 55 N.	25·0	*Rain.*	W	J. S., v. 20, p. 17.
1827. Aug. 17.	14·8	W. 29 N.	12·9	30·0	E. 43 N.	10·0	*Rain.*	W	J. S., v. 31, p. 123.
1830. Aug. 12.	17·3	W. 23·5 N.	23·8	31·4	E. 37 N.	16·3	Rain.	W	J. S., v. 20, p. 34.
1830. Aug. 22.	22·3	W. 27 N.	18·7	30·3	E. 40 N.	16·0	Rain.	W	J. S., v. 20, p. 39.
1830. Sept. 29.	20·2	W. 33·5 N.	26·4	30·4	E. 43 N.	29·6		W	J. S., v. 20, p. 42.
1831. Jan. 13.	30·0			30·0	E. 53·5 N.	16·6	Snow.	W	U.S. N. Mag. 1836.
1831. June 23.	10·3	W. 14·5 N.	20·4					W	J. S., v. 31, p. 123.
1831. Aug. 10.	12·3	W. 25·5 N.	16·6	30·7			*Rain.*	W	J. S., v. 21, p. 192.
1835. Aug. 12.	16·3	W. 17 N.	17·8				Rain.	W	J. S., v. 31, p. 124.
1835. Sept. 3.	12·4	W. 38 N.					*Rain.*	R	Law of Sts., p. 36.
1837. July 26.	11·0	W. 29 N.		30·0			Rain.	R	Law of Sts., p. 48.
1837. Aug. 2.	17·3	W. 31·5 N.					*Rain.*	R	Law of Sts., p. 48.
1837. Aug. 12.	17·6	W. 20 N.		31·7	E. 24·5 N.		Rain.	R	Law of Sts., p. 69.
1837. Aug. 24.	32·7				E. 47 N.	17·5	*Rain.*	R	Law of Sts., p. 109.
1837. Sept. 27.	15·7	W. 24 N.	8·3	26·2	E. 17·5 N.	13·4	*Rain.*	R	Progress, p. 13.
1839. Sept. 12.	18·5	W. 26 N.		32·2			*Rain.*	R	Progress, p. 39.
1842. Aug. 30.	21·6	W. 1 N.	10·0				Rain.	W	J. S., v. 1, p. 2.
1842. Oct. 2.	20·0				E. 18 N.	10·6	*Rain.*	W	J. S., v. 1, p. 153.
1844. Oct. 4.	18·6				E. 54 N.	30·4	*Rain.*	W	J. S., v. 2, p. 312.
1846. Sept. 11.	13·8	W. 62 N.	10·3	29·2	E. 47 N.	14·3	*Rain.*	W	J. S., v. 18, chart.
1846. Oct. 6.	14·2	W. 60 N.		30·0	E. 60·5 N.	23·5	Rain.	W	J. S., v. 18, chart.
1847. Oct. 10.	12·8	W. 11·5 S.	21·2				Rain.	R	Progress, chart.
1848. Aug. 22.	15·0	W. 28·5 N.		27·4	E. 22 N.			R	Progress, p. 337.
1848. Aug. 29.	15·0	W. 22 N.		29·0	E. 24 N.		*Rain.*	M	Phys. Geog., p. 60.
1850. Sept. 2.	16·0	W. 5 N.	13·8					W	J. S., v. 18, p. 176.
1851. Aug. 16.	13·5	W. 15 N.	17·5	27·3	E. 34 N.	18·7	Rain.	W	J. S., v. 18, chart.
1853. Aug. 30.	12·5	W. 12·5 N.	25·3	31·7	E. 24·5 N.	28·4	Rain.	W	J. S., v. 18, p. 1.
1853. Sept. 26.	28·8			29·2	E. 27 N.		Rain.	W	J. S., v. 18, p. 180.
1853. Sept. 29.	13·9	W. 9 N.					*Rain.*	W	J. S., v. 18, p. 178.
1866. Oct. 1.	19·0	W. 15 N.	15·0	26·4	E. 25 N.	30·0	Rain.	B	Han. Book, p. 151.
1867. Oct. 29.	18·5	W. 2 S.	15·5				Rain.	E	Pamphlet.
1871. June 1.	23·5	W. 14 N.	12·3	31·5	E. 45 N.	23·5	Rain.	S	Rep. 1872, p. 282.
1871. Sept. 5.					E. 38 N.	15·0	Rain.	S	Rep. 1874. Map.
1873. Aug. 18.	20·0	W. 32 N.	12·3	33·0	E. 37 N.	18·4	Rain.	S	Rep. 1873, p. 1029.
1873. Aug. 20.	25·0	W. 51 N.	10·5	34·3	E. 41 N.	16·4	Rain.	T	Met. Soc., v.2, p.15.
1873. Oct. 6.	21·3	W. 28 N.	9·5	24·3	E. 45 N.	30·1	*Rain.*	S	Monthly Map, '73.
1874. Feb. 7.	24·0			26·5	E. 45 N.	23·5	Rain.	S	Rep. 1874. Map.
1875. Sept. 14.	23·0	W. 22 N.	25·1	28·5	E. 24 N.	29·6	*Rain.*	S	Monthly Map.

In column 8th the word rain when italicized signifies *hard rain;* when in capitals it signifies VERY HARD RAIN, or rain descending in TORRENTS. It will be perceived that rain generally accompanies hurricanes. In four of the cases I find in the published reports no mention of rain, but it is presumed that this is simply an oversight, since in most of the other cases rain is only incidentally mentioned. In all the investigations of Redfield and Reid the circumstances upon which they insist as specially important are the direction and force of the wind; and it is only by consulting the extracts from the log-books which they have furnished us, that I have discovered any mention of accompanying rain. It is believed that tropical hurricanes *never* occur without rain, and generally the rain is described as descending in *torrents.*

Further remarks upon the preceding table are reserved for a future article. In preparing the materials for this article, I have been assisted by Mr. Edward S. Cowles, a graduate of Yale College of the class of 1873.

ART. II.—*The Colorado Plateau Province as a Field for Geological Study;* by G. K. GILBERT.

I. *Definition and Description of the Province.*

IN the Mississippi Valley and "the Plains" the strata are almost undisturbed and lie nearly level. They have, indeed, been lifted above the parent ocean, and in part raised to a height of thousands of feet, but broad areas have moved together and all flexures have been gentle. There are no traces of the foldings which characterize the Appalachian region. The prevalent features of topography are plains and hills.

From the western edge of the Plains to the Pacific Ocean the characteristic features are mountains. The strata are bent and broken, and upturned at all angles. The typical structures are structures of displacement. Within this region of great disturbance is a restricted area of comparative calm. Dislocations of strata are not unknown in it; indeed, they are of frequent occurrence; but they are less frequent, less profound, and less complex, than in the surrounding region of mountains. Its mountains are few and scattered, and its typical topographic form is the table or plateau. It is called the Colorado Plateau province.

This region of plateaus was crossed by many lines of early exploration, and the salient features of its topography were described by numerous observers. The first writer who called attention to the extent of the district, and colligated the north-

ern portions with the southern, was Professor W. P. Blake (Pac. R. R. Repts., vol. iii, part IV, pp. 8 and 42, 1856.) The title of "Colorado Plateau" first appeared in the map of Ives' Colorado River Report in 1861, and was written between San Francisco mountains and the Grand Cañon. Later usage extended the term to include the broad upland through which the Colorado has excavated its deep channel; and finally, as the minor plateaus of which the great one is composed began, in the progress of geographical knowledge, to be discriminated and named, the comprehensive title of the whole became *the Colorado Plateaus* or *the Colorado Plateau Province*. Portions of the region have been studied, described, and mapped by numerous geologists and geographers, but the chief contributions to our knowledge of the Province as a whole, and of its limits, have come from the surveys conducted by Major Powell and Lieutenant Wheeler.*

It would avail little to describe in detail the boundaries of the province without the aid of a map. On the east it is separated from the Plains by a continuous broad belt of mountains, which include the parks of Colorado and have been called the Park Mountain System. On the south and west it adjoins the Basin Range Province, a region of many short parallel ranges, separated by trough-shaped, desert valleys. Northward it is limited by mountains for which there is no comprehensive title. Its greatest extent from north to south is 700 miles; from east to west, 425 miles. It comprises, of southern Wyoming, 20,000 square miles; of eastern Utah, 50,000; of western Colorado, 30,000; of northeastern Arizona, 45,000; and of northwestern New Mexico 25,000;† making a total of 170,000 square miles, or one-twenty-fourth part of the territory of the United States. It is drained chiefly by the Colorado of the West and its tributaries, but the Sevier river heads in the western margin, and the Puerco of the East in its eastern, and the North Platte drains its northeastern angle. The plateaus which compose it range in altitude from 5,000 to 11,000 feet above the sea, but the lines of drainage are much lower, and the streams run at the bottoms of deep gorges or cañons. The plateaus are terminated in part by cliffs, and the cañon walls are cliffs. Plateaus, cañons, and cliffs are the characteristic features. The chief mountains are of volcanic origin, and they are doubly conspicuous, since

* Exploration of the Colorado River of the West and its tributaries; by J. W. Powell. Washington, 1875.

U. S. Engineer Explorations and Surveys west of the 100th meridian, vol. iii, Geology; by G. K. Gilbert, Archibald R. Marvine, Edwin E. Howell, and J. J. Stevenson. Washington, 1876.

† In defining the province in my report to Lieut. Wheeler (see U. S. Eng. Expl. and Sur. W. of the 100th mer., vol. iii, Geology, pp. 43 and 542) I have not included the portion south of the Uinta mountains. I was not aware, at the time of writing, that the plateaus south of the Uintas were continuous with those of Wyoming, the Uinta uplift not extending eastward to the Park Mountains.

they not only constitute some of the loftiest points, but are exceptional to the general character of the topography.

The climate is extremely dry—so dry that agriculture is impossible without irrigation. Vegetation is scant, except upon the heights. Below 8,000 feet altitude it is too sparse to interfere with the examinations of the geologist, and there are vast stretches of absolutely naked rock. Travel is greatly obstructed, except along certain lines, by deep cañons which ramify through the plateaus, and the selection of routes for wagon-roads and railroads is a work of great difficulty.

All this description applies more especially to the southern portions of the district. North of the Uinta mountains the streams flow in shallower and broader valleys, and are more sluggish. The Green river, the main artery of drainage, is there less deeply sunken in the plain than in its lower course, and all erosion by running water is hence less powerful. The profiles of the topography are more rounded, and accumulations of local drift and soil give rise to many grassy plains.

The only important economic mineral of the whole region is coal, and this, though unlimited in quantity, is now utilized only where the Pacific railroad affords a market. Mines of the precious metals are nearly unknown, and in default of these, which are the usual incentives to settlement in our arid territories, the region is chiefly uninhabited by whites, and portions are even unexplored, except by the ubiquitous trapper and prospector, who make no record of their discoveries. Along the western margin are Mormon settlements. The market afforded by the Pacific railroad and its dependencies, has stimulated a little farming in Wyoming, and the same result has been wrought at the south, in Arizona and New Mexico, by a line of military posts. But in the center of the province one can find a spot that is more than one hundred miles from the nearest house, excepting only the ruined and abandoned dwellings of the Pueblo Indians, who once peopled this forbidding land more densely than it is likely ever to be peopled again.

II. *How the material is exposed for study.*

As a field for the studies of the geologist, the Plateau province offers valuable *matter* in an advantageous *manner*. Let us begin with the consideration of the manner.

First, the Climate. The air is so dry that, except on the heights and at the margins of springs and streams, there is no turf, no accumulation of humus, often no soil, and so little vegetation that the view is not obstructed. From a commanding eminence one may see spread before him, like a chart, to be read almost without effort, the structure of many miles of country, and in a brief space of time may reach conclusions, which, in a

humid region, would reward only protracted and laborious observation and patient generalization. There is no need to search for exposures where everything is exposed. Dr. Newberry, speaking of one of the southern plateaus, says, "On our way to the Moqui villages we passed through a region singularly favorable for accurate geological investigation; where there is no vegetation to impede the view; where the strata are entirely undisturbed, and are cut by valleys of erosion, in the wall-like sides of which every inch of the series may be examined. In this journey we ascended in the geological scale from the summit of the Carboniferous to the base of the Cretaceous series. Of this interval there is no portion of which the exposures are not as complete as could be desired." (Geol. Ives' Exped., p. 77.)

This aridity is not peculiar to the plateaus: it pertains to the Basin Ranges, and in a less degree to the plains. But in the ranges the most arid portions are the valleys between the mountain ridges, and these are filled with monotonous Quaternary gravels and clays, which hide all other beds, while the ranges themselves, which are of more interest to the geologist, catch all the precipitation, and are in some degree clothed with verdure.

Second, the Drainage. The Plains and the Plateaus are alike drained by great rivers, which rise in lofty mountain regions, and traverse them on their way to the sea; but there the resemblance ceases. The rivers which cross the Plains flow over them in broad shallow valleys. The soft rocks of the intervening benches decay more rapidly than they are undermined, and their rounded outlines are clothed with soil. But the Colorado and its branches flow across the Plateaus in deeply carved, narrow cañons. Where the Green river, which is the main fork of the Colorado, enters the Uinta mountains, it is 2,000 feet below the adjoining plateau, and where the Colorado leaves the plateaus, it emerges from a gorge 4,000 feet deep. In the interval the current courses, almost without exception, between high cañon walls. Into this deep channel are gathered the waters of the uplands. Empowered by the rapidity of its descent, each tributary river has carved a cañon of its own, and so too has each branch and creek tributary to a river, until the whole tract is divided by a labyrinth of ramifying cañons. When the rain falls—for it does sometimes fall here—it flows down rapidly into the gorges, and washes with it the loosened particles of disintegrating rock. Then in time of flood the deepening waters, constrained to a narrow channel, rush forward with impetuous velocity and sweep out the detritus. The rocks of the upland are removed as fast as they decay, and soil cannot accumulate. Thus does thorough drainage conspire with aridity to prepare for the geologist a land of naked rock.

No less important to the student are the cañons themselves. They bear the same relation to a plain that geological cross-sections do to a geological map. They introduce in all categories of observation a third dimension, and enable the contemplation of all the phenomena of structure with reference to depth as well as length and breadth.

Third, Glacial drift and Lava-sheets. While these are, in themselves, fertile subjects of study, they are also obstructions to observation, in so far as they conceal other formations from view; and it is as obstructions that I here refer to them.

Moraines are unknown in the southern half of the Plateau province, and in the northern they are not found at a lower altitude than 7,500 feet. The few that exist pertain to what were local glaciers. There was no general ice-mantle. The southern limit of glacial phenomena is in north latitude 38° 30′, or about on the parallel of St. Louis. In the epoch of ice the climate of the Plateaus doubtless bore the same relation to that of the eastern seaboard that it does now. It was then, as now, a little colder than the latter, and a great deal drier; and it was its dryness which prevented, even at an altitude of some thousands of feet, the accumulation of such a deluge of ice as visited the Atlantic seaboard in the same latitude. Only on the highest mountains was the winter's precipitation in excess of the summer's melting.

But while the mantling by glacial drift is inconsiderable, that by extravasated material is of great extent. Some of the largest continuous lava fields of our country belong to the Plateau region. A field in southern Utah stretches ninety miles from north to south and seventy miles from east to west; and the corresponding dimensions of one in New Mexico and Arizona are one hundred and seventy-five, and one hundred and forty miles. Almost coalescent with the latter is a third field which includes the San Francisco group of peaks in Arizona. Beneath these, and beneath minor floods of lava, are buried a tenth part of the sedimentary rocks of the Plateaus.

In brief, the strata of the Plateau region are exposed with exceptional thoroughness. They are indebted to a dry climate, in ancient and modern times, for the almost entire absence of glacial drift, and for the suppression of vegetation. They are indebted to peculiar conditions of drainage for their poverty of soil, talus, and local drift, and for a system of natural cross-sections. Their chief detraction is a mere restriction of their area of exposure by overlapping lavas.

III. *The material for study.*

It remains to consider the nature of the material which is so fully exhibited, and examine its claims to attention. It pertains chiefly to four departments of geological investigation, viz:

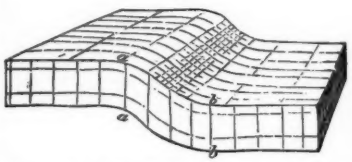
Mountain building by displacement; Mountain building by eruption; Stratigraphy; and Erosion; and will be discussed under these heads, in the order indicated.*

Mountain building by displacement. The Plateau Province differs from the mountain provinces by which it is surrounded in the degree and not in the kind of disturbance to which its sediments have been subject. Faults and folds abound through its whole extent, but they are comparatively of great simplicity. They are indeed so simple that they can be completely known. Their entire phenomena may be comprehended, measured, described, and delineated. The course of many a fault can be traced from end to end, and its throw measured at every step. The form of many a fold can be determined thoughout, and pictured or modelled in miniature, with every detail of flexure.

Now, faults and folds are the *elements* of the displacements which give rise to mountains, and to study them is to study the very rudiments of mountain structure, and to acquire a knowledge of mountain structure is to lay the indispensable geological foundation for a true theory of the origin of mountains. Hence the value of this opportunity to study the elements of displacement in an uncombined condition, and in their simplest compound forms. To enforce this proposition, which is of more importance than might at first appear, I will take an illustration from the material already gathered, and, to do so, it will be necessary to explain one or two terms that have had to be coined to describe the new group of facts.

In an anticlinal fold the strata dip in two directions away from the axis. In a synclinal fold the strata dip from two directions toward the axis. There is in nature a third type, which involves a dip in only one direction. This is the *monoclinal* fold. It is a double flexure, connecting strata at one level with the same strata at another level. In figure 1, the curvature between *aa* and *bb* is a monoclinal fold.

1.

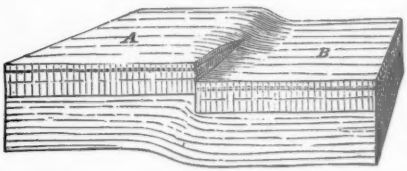


* The writer travelled, during three summers, with field parties of the Survey in charge of Lieut. George M. Wheeler of the U. S. Engineers, and during a fourth with a field party of the Survey in charge of Major J. W. Powell. His reports to Lieut. Wheeler are published in the third volume of the reports of "Explorations and Surveys west of the 100th meridian." Besides his own observations, the chief sources from which he has derived the material here presented, are: 1. The observations of Major J. W. Powell, published in his report on the "Exploration of the Colorado River of the West and its tributaries;" and, in part unpublished. 2 and 3. The observations of Mr. E. E. Howell and of the late Mr. A. R. Marvine, published in vol. iii, of Lieut. Wheeler's Reports, and in part unpublished. 4. The observations of Dr. J. S. Newberry, published in Ives' "Explorations of the Colorado," and in part unpublished. 5. The writings of Mr. Clarence King, "Fortieth Parallel Survey," vol. iii. 6. Mr. T. B. Comstock's report in the U. S. Engineers' "Reconnaissance of northwestern Wyoming." 7. Prof. E. D. Cope's report to Lieut. Wheeler, published in the U. S. Engineer report for 1875.

It is evident that if two monoclinal folds are combined back to back, the result will be an anticlinal; if they are joined foot to foot, they will form a synclinal. Hence the monoclinal fold is a simpler element of displacement than either of the others.

When a portion of the earth's crust—it may be one that is measured by miles, or one that is measured only by feet—is moved bodily either up or down, while the portion adjacent to it is not so moved, the line along which they adjoin, will be marked by a fault, by a monoclinal fold, or by some combination of the two. The fault and the monoclinal fold are alternative manifestations of simple displacement, and are, in a certain sense, equivalent. There are several different ways in which they are combined with each other. If one travels along the line of displacement that separates two blocks of strata which stand at different levels; he may find that at one point the beds are continuous, and curve downward from the upper level to the lower; and that at another point they are broken across, and the dissevered edges have slidden past each other.

2.



Or, if one could descend into the earth along the plane of dislocation, he might find that one stratum had been fractured, while another, less rigid, or coerced perhaps by a greater pressure of superincumbent rock, had been only flexed. A third mode of combination is exhibited when a bed yields at first by flexure, and is finally fractured before the completion of the dislocation. These phenomena are illustrated by figure 2, which is an ideal representation of two blocks of strata, *A* and *B*, cut out from their surroundings, so as to exhibit the manner of their relative displacement. The front of the segment shows a flexed bed underlying a faulted one. The top of the segment shows a fault at the front, a monoclinal fold at the back, and a compound displacement midway.

The monoclinal fold is not unknown in other parts of the world, but it has attracted little attention, and I am not aware that it has been described as abundant in any region. But in the region of the Plateaus it is not merely a feature of occasional occurence; it is a characteristic type of displacement, and is rivalled in frequency only by the fault.

Let us now turn from the displacements, to the disturbed masses of rock which they divide. A fault or a monoclinal fold is merely the record, at the margin of a solid block, of a movement that has affected the entire block, and it bears the same subsidiary relation to the movement of the block, that a

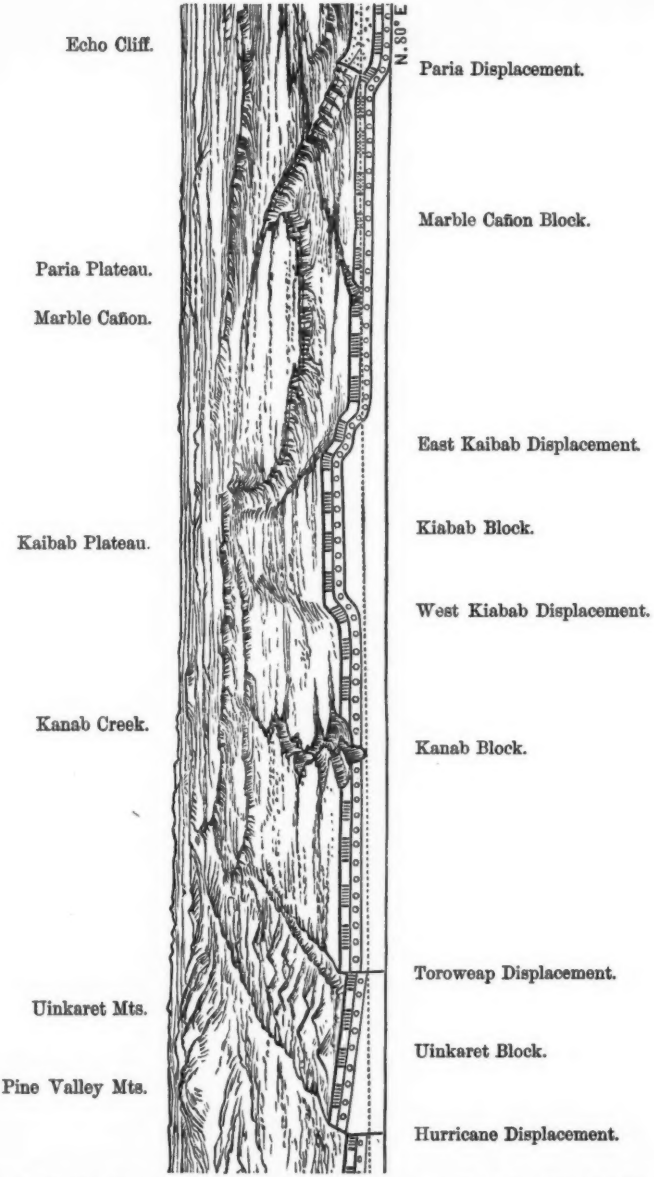


Fig. 3. Section from west to east across the plateaus north of the Grand Cañon of the Colorado, with bird's-eye view above. Horizontal scale, 16 miles to the inch; vertical scale, 4 miles to the inch. The base line marks the level of the ocean; the dotted line above it, the level of the river.

line bears to the angle or area which it limits and defines. A large portion of the Plateau region is divided into great blocks —usually a few miles in width and many miles in length—and these have been unequally lifted above the ocean which deposited their common sediments, so that each differs from its neighbor in altitude. They are bounded by lines of displacement. The blocks which have been lifted highest have been most exposed to erosive agencies, the tendency of which is to pare away eminences and reduce all to a common level: but as a rule, the highest plateaus mark the positions of blocks that have risen above their neighbors. The forms of many blocks are perfectly portrayed in the topography, and all can readily be traced out and defined by the study of the displacements.

In illustration I have borrowed, through the kindness of Major Powell, a wood-cut from his report of the "Exploration of the Colorado," and if the reader will examine it attentively, he will obtain a clearer idea of the structure I have described, than I can hope to convey in words. The sketch is not an ideal one, but was carefully drawn to represent a tract of country, lying in Utah and Arizona, of which the main geological features are clearly understood. The geological section in the foreground is, in the main, the section which is exposed in the walls of the Grand Cañon, and is 106 miles long. The vertical scale is four times as great as the horizontal. The base line marks the level of the ocean, and the dotted line the level of the Colorado river. The rock bed marked with small circles stands for the Lower Aubrey Group, a member of the Carboniferous System; the one above it for the Upper Aubrey Group, also Carboniferous, and the dotted stratum, seen at the right, is the so-called Trias. In the bird's-eye view beyond the section, the foreground is of plateaus floored by the limestone of the Upper Aubrey, and beyond rise terraces built of Triassic and more recent strata. Five displacements are exhibited. Beginning at the left: the Hurricane displacement is a fault where it is intersected by the section, and has a throw of 2,500 feet. Seventy miles farther north it is a combination of fault and fold. The throw of the To-ro′-weap fault is only 800 feet, and it disappears altogether in a few miles. The West Kai′-bab displacement is a monoclinal fold as far as it appears in the sketch, but farther south it changes to a fault. Its throw is 2,000 feet. The East Kaibab displacement is a double monoclinal fold in the foreground but a single one in the distance. Its total throw is 3000 feet. The throw of the Paria displacement is 1800 feet. It is known only as a simple fold. Along the lines of the first three displacements the eastern wall has risen, or the western has fallen; but with the remaining two the reverse is the case.

[To be continued.]

ART. III.—*Notices of Recent American Earthquakes*—No. 6; by Prof. C. G. ROCKWOOD, Jr., Rutgers College.

IN the following notices, facts given by *single* newspaper reports, and which could not be otherwise verified are printed in smaller type, and the source from which they were obtained is indicated.

For information received I am indebted to John M. Batchelder, of Boston, and Samuel Barnet, of Washington, Ga.

1874.

May.—The disturbances at Bald Mountain, N. C., in February and March, already noticed (III, ix, p. 332) were reported as continuing at intervals during the months of April and May. (U. S. Signal Service.)

July 23.—A light shock at Camp Russell, Neb. (U. S. Sign. Serv.)

Aug. 3.—During the evening a light shock from the east at Clifton, San Bernardino Co., Cal. (U. S. Sign. Serv.)

Dec. 12.—A slight shock between 10 and 11 P. M at Garrison's, N. Y.

1875.

January.—Earthquakes preceded and accompanied an eruption of the volcano Trölladyngja, in the central part of Iceland. The volcanic disturbance appears to have begun by subterranean thunders during December, 1874, extending through nearly two-thirds of the island. Early in January, 1875, earthquakes occurred in all directions and then an old extinct volcano near Vatrayskud opened and for four weeks continued to emit ashes, lava, etc. When this eruption ceased, another extinct volcano near Myvatu, 100 miles farther north, opened and continued in action for several weeks. Both of these eruptions occasioned great destruction of life and property. Early in March there seemed to be a general upheaval of the earth in the whole central portion of the island. The ashes from these or still later eruptions fell to the depth of several inches on the coast of Norway in the latter part of April. It is stated that "the geysers have dried up since the eruption began, and instead of water emitted quantities of hot smoke and ashes."

Jan. 24.—A heavy shock at 4 A. M. in Butte, Plumas, and Sierra counties, Cal.; felt also at Sacramento, Cal., and Carson City, Nev., where two shocks were reported, the first light, the second quite severe and lasting several seconds. The direction was from the northeast.

Feb. 7.—Two severe shocks at San Francisco, Cal., the first at 10.56 and the second at 11.50 A. M., each lasting two to four seconds. (U. S. Sign. Serv.)

Feb. 16.—A shock at Orezava and Minatitlan on the Isthmus of Tehuantepec. (J. M. B.)

Feb. 11 and 18.—A letter from Guadalajara, Mex., dated March 2, 1875, says: "Since the 11th ult. we have had almost continually slight shocks of earthquake. In all we have had but four very severe shocks; the first (two?) on the night of the 11th and two on the 18th. The majority of the churches in Guadalajara are greatly damaged. In San Cristobal, a small village about eight leagues from this city, 35 or 40 lives have been lost and nearly all the houses reduced to ruins."

March 9 and 10.—The same writer says under date of March 10: "The earthquakes continue. We had one yesterday that lasted three minutes, not severe. We felt a sharper one to-day at 1.20 P. M. but it only lasted a few seconds."

March 9.—A shock at Phœnix, R. I. (J. M. B.)

April 1.—A heavy shock in the evening at Eureka, Nev. (J. M. B.)

May 6.—A shock at Wolfborough, N. H. (J. M. B.)

May 15.—A slight shock about 10.15 A. M. at Cambridge, West Roxbury and Milton, Mass.

May 18.—A very destructive earthquake occurred at 10.10 A. M. in the Colombian Andes. The area affected extends from Carthagena and Maracaybo on the north to Bogota and Honada on the south, over six degrees of latitude. The center of disturbance was at the city of San José de Cucuta. This is a city of Venezuela, situated on the border of New Grenada, in N. lat. 7° 30′, W. long. 72° 10′, and before the catastrophe had a population of 18,000. It is between the two ranges of the Andes which unite not very far south of the city. The first premonition of the disturbance at Cucuta was a subterranean rumbling noise heard on the night of the 17th, but unattended by any tremors. At 11.10, (some accounts 11.30) on the forenoon of the 18th two tremendous shocks of earthquake occurred followed after a short interval by three others of nearly equal intensity. By these shocks, the city and most of the surrounding villages within a radius of twenty miles were completely destroyed, with great loss of life and property. In Cucuta only one building remained standing; and in San Cristobal (population 11,000) only one house was left and that so shattered as to be unsafe.

The destruction involved nine villages in Venezuela, chiefly in the department of Merida, and ten in New Grenada in the departments of Santandar and Pamplona. The loss of life is estimated at 5000, and of property at $7,000,000. Immediately after the first shocks, the Lobotera volcano, near the city, began to emit masses of molton lava, which falling in the city set fire to the ruins, and thereby added to the destruction, the

horrors of which were still further enhanced by the pillage and robbery which took place. Lighter shakings were felt in various parts of this region for a number of days after the first shock. Thus advices from Maracaybo, May 29, say: "Light shakes here every day since." In Cucuta, Trujillo, Merida, and Mendoza, "tremors perceptible at intervals for forty-eight hours." A telegram from Bucaramanga, May 24, says: "The earthquake continued last night. The cathedral in Pamplona fell." A telegram from Chiquinquira, May 22, says: "the shocks are repeating. Two last night, one to-day." It was noticed as a remarkable fact that the disturbance was only felt on the west side of the mountain range.

May 18.—A prolonged shock just before midnight at St. Thomas, W. I. (J. M. B.)

May 30.—Advices of this date from City of Mexico say: "slight shocks have been felt in Jalisco." (N. Y. Times.)

June 4.—A shock at 3 A. M. felt on board the ship Hamilton in N. lat. 19° 16′, W. long. 57° 51′. "When the disturbance first began the sea was quite smooth, but as the shock increased in violence the waters became correspondingly agitated. Suddenly the vessel received a shock as if she had grounded, and a peculiar rumbling noise filled the air. Simultaneously with the shaking the sky assumed a dull leaden hue. The atmosphere was also thick and hazy. There was little if any wind at the time, yet the vessel was tossed about as though in the midst of a gale. The duration was long enough to enable those who were below to reach the deck, estimated as fully ten minutes."

June 13.—Several shocks at Chinaltenango, San Salvador.

June 16.—A shock at San Francisco, Cal. (J. M. B.)

June 18.—A shock in the forenoon in western Ohio and Indiana. It was most severe in the vicinity of Urbana and Sidney, Ohio, where walls were cracked, chimneys thrown down, etc.; but it was sensibly felt at Columbus, O., and Indianapolis, Vincennes and Jeffersonville, Ind., and slightly at Cincinnati and Chicago. It was not felt at Terre Haute, nor in the vicinity of Lafayette and Logansport, Ind. The statements in regard to time are various and contradictory. The United States Signal Service Observer at Indianapolis reports the shock as occurring at 7.43 A. M. All other accounts vary from 9 to 11 A. M. *No account mentions more than one shock.*

Slight shocks were felt in San Francisco on the same forenoon.

July 3.—Three shocks at 12.05 P. M. at Nuevitas, Cuba. The first and last slight, the second rather severe, the whole lasting about fourteen seconds. (N. Y. Times.)

July 28.—A shock at 4.10 A. M. felt quite generally through-

out the northwestern part of Connecticut. It extended from Hartford and Springfield on the east to the line of the Housatonic R. R. on the west, and from Danbury and Waterbury on the south, to Chester and Becket, Mass., on the north, being felt at numerous places in Litchfield and Hartford counties. At most places the shock was preceded or accompanied by a rumbling noise. At Collinsville it lasted fifteen seconds. At Winsted it is stated to have lasted forty seconds, the sound coming from the north and passing away toward the south.

July 28.—A shock at 6.05 P. M., at Milledgeville, Ga., with a loud explosion. (Atlanta Herald.)

July 31.—Advices of this date from the City of Mexico, report an earthquake in Jalisco. (N. Y. Times).

Aug. 3.—A shock at 3 A. M. in St. Thomas, W. I.

Aug. 8.—A heavy shock in the morning at Hollister, Cal. (J. M. B.)

Aug. 29.—A shock was felt at 8.30 P. M., on board the bark St. Lawrence, in N. lat. 18° 50′, W. long. 61° 30′, being between St. Thomas and the Island of St. Bartholomew, 140 miles from land. It lasted thirty seconds. (N. Y. Herald.)

Sept. 17.—Three shocks at St. Vincents, W. I. The last about 9 P. M. was rather severe. (London Times Correspondence.)

Sept. 25.—A shock about 9 P. M. at Stepney, Conn. (New Haven Palladium.)

Oct. 7.—Slight shocks at Memphis, Tenn., and Cairo, Ill. (U. S. Sign. Serv.)

Oct. 14.—A sharp shock about 6 P. M. at San Francisco, and in the Santa Clara Valley, Cal. The vibrations were from east to west. Reports from various points on the coast from Santa Cruz to Cape Mendocino, mention a heavy sea without wind, and the waves rolling up on the beach 100 to 300 feet beyond the usual high water mark, for several days after the above. From this it might be inferred that this earthquake had its origin somewhere in the Pacific Ocean.

Oct. 15.—A shock at 1 A. M. at Kingston, Jamaica, W. I. (J. M. B.)

Oct. 27.—Three shocks in the night at Memphis, Tenn.; strong enough to rattle windows. Also a shock, probably the same, at 9 P. M. at Purdy, McNairy Co., Tenn.

Oct. 31.—A slight shock at 9.18 P. M. at Cambridge, Mass., of three or four seconds duration. Barometer 29·70 in.

Nov. 1.—A somewhat severe earthquake was felt at 9.55 P. M., in the northern part of Georgia. It was felt at Gainesville, Atlanta, Madison, Athens, Union Point, Washington, Augusta, Forsyth and Macon, Ga., and at Spartanburg and Columbia, S. C. It lasted about thirty seconds, and at Wash-

ington and Augusta some observers noticed two or three shocks. A rumbling was heard at the former place. The reports of the direction of vibration are too contradictory to be briefly stated. No damage was done, but the shock was sufficiently strong "to cause a mirror to nod back and forth from the wall."

Nov. 2.—Advices of this date from San Francisco say: "A severe shock of earthquake is reported at Fort Yuma on the Colorado River."

Nov. 7.—A heavy shock in San Benito County, Cal., accompanied by a harsh rumbling noise. The direction of vibration was from east to west.

Nov. 8.—A shock at 4.40 A. M., felt at Leavenworth, Lawrence, Burlingame (direction S.W. to N.E.), and Manhattan, Kansas. At the latter place the time was "about 5 A. M.," the direction west to east and lasting a minute.

Nov. 12.—A shock at 2 A. M. at Knoxville, Tenn., lasting ten seconds. The vibration was from west to east, and accompanied by a rumbling noise.

Nov. 14.—A shock at San Francisco and San Jose, Cal. (U. S. Sign. Serv.)

Nov. 15.—A smart shock at 7.55 P. M. at San Francisco, Cal.; vibrations east and west.

Nov. 27.—A shock at San Francisco, Cal. (U. S. Sign. Serv.)

Dec. 1.—Two slight shocks at 4 and 6 A. M. at Keene, N. H.

Dec. 3.—A heavy shock in the afternoon at Grass Valley, Cal., lasting ten seconds, vibrations north and south. Felt slightly at 3 P. M. at Carson City, Nev.

Dec. 4.—The town of Abancay, Peru, was destroyed by an earthquake, "between 4 P. M. of the 4th and 9 A. M. of the 5th, no less than thirty-seven shocks occurred, some of them very severe" This town is east of the Andes and some fifty miles from Cuzco.

Dec. 8.—On the night of the 8th and 9th, an earthquake occurred in Porto Rico by which the town of Arecibo was almost entirely destroyed, "two churches and only six houses remaining."

Dec. 8.—On the same day as the preceding, hour not stated but apparently about breakfast time, the bark Mora experienced an earthquake at sea in N. lat. 10° 7′, W. long. 42°.

Dec. 9.—A slight shock at 3 A. M. at Nebraska City, Neb.

Dec. 15.—A shock at 2.45 P. M. at Maricopa Wells, Arizona Terr. (U. S. Sign. Serv.)

Dec. 21.—A shock at Santa Barbara, Cal. (U. S. Sign. Serv.)

Dec. 22.—An earthquake was felt about 11.45 P. M. in Virginia. It was most severe at Richmond and vicinity, where three distinct shocks were noticed, lasting twenty or thirty

seconds, and accompanied by a rumbling noise. The shocks "were not sharp or sudden, but coming on rather slowly, swelling in force, and then quickly dying out." The direction of the vibration was north and south, and it was sufficiently strong to knock down plastering, etc. It was felt toward the north as far as Washington and Baltimore, and toward the northwest at Staunton and Gordonsville, at which latter place the time is stated at 11.30, and the duration "fully three seconds." The U. S. Signal Service reports: "Two shocks at 11.30 at Fortress Monroe, Va.; about 11.30 at New Market, Ind.; shock lasting twenty seconds at 11.45 at Greensboro, N. C.; two shocks from east-southeast to north-northwest, the first lasting five or six seconds, the second not quite so heavy at 11.40 (Washington time) at Alto Vista, Va.; two shocks from east to west, first lasting ten or fifteen seconds, the second milder, at 11.33 at Petersburg, Va.; shock from northeast to southwest with rushing roaring noise at Weldon, N. C."

Dec. 23.—A shock at night in Placer, Nevada and Yuba Counties, Cal.

Dec. 24.—A shock in the evening at Grass Valley, Cal. (N. Y. Times.)

1876.

Jan. 7.—Three shocks at the Island of St. Thomas, W. I., in the morning, "the first at about four o'clock, the second at about half past four, which was very severe, and the last three minutes later." (Newark Daily Advertiser.)

Jan. 7.—A shock at 2.20 P. M. at Warner and Contoocookville, N. H. Its apparent course was from west to east and its duration two minutes.

Jan. 8.—A shock at 4.30 P. M. at Lockport, N. Y. (U. S. Sign. Serv.)

Jan. 15.—A severe shock at midnight at China, Me.

Jan. 21.—A shock between 3 and 4 A. M. at San José, Santa Cruz and San Francisco, Cal. (U. S. Sign. Serv.)

Jan. 27.—Two shocks at Adrian, Mich. (U. S. Sign. Serv.)

Jan. 29.—A shock at 9.05 P. M. at Annapolis, Md. (U. S. Sign. Serv.)

Feb. 7.—A shock in the City of Mexico. (U. S. Sign. Serv.)

Feb. 27.—A shock at Detroit, Mich.

March 25.—Two slight shocks at 6 A. M. and 1 P. M. at Oakland, Cal. (U. S. Sign. Serv.)

April 10.—A shock was felt in a large portion of St. Mary's County, Md., attended by a rumbling sound. (N. Y. Times.)

New Brunswick, N. J., May 3, 1876.

ART. IV.—*On Roscoelite, a Vanadium Mica;* by JAMES BLAKE, M.D., San Francisco, California.

THE mineral, to which I have given the name of Roscoelite, —in honor of Professor Roscoe, of Manchester, who has done so much for the chemical history of vanadium,—is a well marked species of mica, containing quite a large percentage of vanadium. It was found in a gold mine at Granite Creek, El Dorado County, in the lower hills on the western slope of the Sierra Nevada. It occurs in the hanging wall of a small quartz vein, the country rock being porphyry. The mica appears to have been principally deposited in fissures in the porphyry, and is usually found in layers from a tenth to half an inch thick, and seldom extending continuously for more than two or three inches. It is also found filling cavities in the quartz. The crystals are quite brilliant, of a dark-green color, seldom more than 0·1 inch long, and, when occurring in fissures, form two series starting from each side of the fissure and meeting in the center. They are also found in nodules with a stellar arrangement, more particularly in the cavities of the quartz. They are strongly doubly refracting. Sp. gr. 2·33. They weather into a light yellow wacke. The whole thickness of the vein-matter in which the mica is found is not more than a few inches. The mine in which it occurs has been worked for gold, and it is in these micaceous deposits that the greater part of the gold is found. Some portions are extremely rich, as much as $240 having been washed out from a single panfull; and while at the mine I saw $40 taken from a few handsfull. The gold is commonly found in the form of fine scales which have been deposited between the crystals of the mica. So generally is it diffused that it is impossible to find a piece of the mica as large as a bean that does not contain gold. The mine is worked by means of an open cut, now about 30 feet deep and 150 feet long.

The most interesting fact connected with this mineral is the large proportion of vanadium it contains, and that too, in a form in which it has not before been found, unless the small traces of it detected in some basalts should be part of an analogous compound. When I first discovered the mineral, I expected to find a mica rich in chromium, and, on heating some of it in a test tube with HCl, I obtained a green solution. Finding that by continued boiling with acid the whole of the color was entirely removed from the mica, I availed myself of this method to determine the quantity of what I considered to be chromium; fusing the residue from the acid solution with carbonate of soda and niter, and precipitating with lead, I also ascertained the amount of the alkalies; and, in presenting some specimens

of the substance to the Microscopical Society and at the Academy of Sciences of California in September, I made the general statement that it was a potash-mica, containing 23 per cent chromic oxide and traces of lithia. It was not until I had sent a specimen of the mineral to Dr. Genth to analyze that the presence in it of vanadium was discovered, and to him is due the entire credit of having first detected the true character of this interesting mineral. I have availed myself of the action of nitrohydrochloric acid on the mineral to prepare a considerable quantity of vanadic compounds for physiological experiment, as this affords about the easiest method of obtaining vanadic acid, although it is impossible thus to extract all the vanadium from the mica.

ART. V.—*On some American Vanadium Minerals;* by F. A. GENTH.

1. *Roscoelite.*

I am indebted to Dr. James Blake of San Francisco, California, for a small quantity of the very interesting mineral, which he called "Roscoelite," in honor of Professor Roscoe, whose important investigations have put vanadium in its proper place among the elements.

Roscoelite occurs in small seams, varying in thickness from $\frac{1}{25}$ to $\frac{1}{15}$ of an inch in a decomposed yellowish, brownish or greenish rock. These seams are made up of small micaceous scales, sometimes $\frac{1}{4}$ of an inch in length, mostly smaller and frequently arranged in stellate or fan-shaped groups. They show an eminent basal cleavage. Soft. The specific gravity of the purest scales (showing less than one per cent of impurities) was found to be 2·938; another specimen of less purity gave 2·921. Luster pearly, inclining to submetallic. Color dark clove-brown to greenish-brown, sometimes dark brownish-green.

Before the blowpipe it fuses easily to a black glass, coloring the flame slightly pink. With salt of phosphorus gives a skeleton of silicic acid, a dark yellow bead in the oxidizing flame, and an emerald-green bead in the reducing flame. Only slightly acted upon by acids, even by boiling concentrated sulphuric acid; but readily decomposed by dilute sulphuric acid, when heated in a sealed tube at a temperature of about 180° C., leaving the silicic acid in the form of white pearly scales, and yielding a deep bluish-green solution. With sodic carbonate it fuses to a white mass. The roscoelite, which I received for investigation was so much mixed with other sub-

stances, such as gold, quartz, a feldspathic mineral, a dark mineral and very minute quantities of one of orange color, that it was impossible to select for analysis material of perfect purity. For this reason I have delayed the publication of my results, which were obtained over one year ago, in the hope of being able to repeat my analyses with better and purer specimens; but I now give the results of my analyses because there is no prospect of getting any more of this mineral, as will be seen from a letter of Dr. Blake, dated San Francisco, April 5th, 1876, in which he says, that the mine in which it occurs cannot be worked any farther until a tunnel has been run, and that it is quite uncertain when this will be done.

Although by no means perfect, my results approach the truth and give a fair idea of the composition of the mineral, even if the evident admixture of other minerals, varying in the different samples analyzed, from about one to perhaps over twelve per cent, does not permit one to calculate the atomic ratio of the constituents and establish the constitution of this species. There is especially an uncertainty with reference to the quantities of silicic acid, alumina and potassa which belong to the roscoelite, or which may have been introduced by admixtures of feldspathic and other minerals, as will appear from the results given below, which show that the mineral, when decomposed with sulphuric or dilute hydrofluoric acid generally gives only about six per cent of potassa, while fusion with calcic carbonate and ammonic chloride yields from eight to nine per cent. Some of these uncertainties could have been removed, if a larger quantity of the mineral had been at my disposal.

Particular attention was paid to the correct determination of the vanadium and the form in which it exists in the roscoelite.

The separation of vanadium is attended with great difficulties, and I have not found any of the methods of separation to give fully reliable results. This is in part owing to the incomplete precipitation of the vanadic acid, and in part to the impossibility of washing the precipitates completely without loss of vanadium. It was therefore always determined by the only method which I found to give fully reliable results—by titration with potassic permanganate.

After the separation from the other elements, the vanadic acid was reduced by hydrosulphuric acid into V_2O_4, which, after the excess of hydrosulphuric acid had been expelled by continued boiling, was re-oxydized into V_2O_5 by the permanganate. I have satisfied myself by numerous experiments that, no matter whether only a very minute quantity of sulphuric acid is present, or a very large excess, the V_2O_4 is completely oxidized into V_2O_5 by this process.

For the determination of the state of oxydation of the vana-

dium in the roscoelite, a quantity of the mineral was dissolved in dilute sulphuric acid in a sealed tube at a temperature of about 180° C., and was titered after cooling; the liquid was then reduced by hydrosulphuric acid, and after boiling off the excess of the latter, it was again titered. From the quantity of oxygen required for oxidation in both cases it was found that vanadium in the mineral is present as $V_6O_{11} = 2\,V_2O_3, V_2O_5$.

The determinations of the other elements were made by the usual methods.

The finely-powdered mineral was dried (unless otherwise stated) for two days over sulphuric acid, and the different samples gave the following results:

(*a.*) *Purest scales.*—The analysis was made by dissolving one portion in sulphuric acid and determining in this the quantity and state of oxidation of the vanadium, the silicic acid and insoluble impurities. The latter were left behind in dissolving the silicic acid in sodic carbonate and gave 0·85 per cent; a second portion was decomposed by sodic carbonate and nitrate, and a third for the determination of the alkalies by J. L. Smith's method. The V_6O_{11} given below is the mean of the two determinations. (*b.*) Another sample, not quite as pure as *a*, was analyzed by fusion. (*c.*) Still more contaminated with impurities, was analyzed by dissolving in dilute sulphuric acid in a sealed tube, &c., $c\alpha$ is the result of this analysis, $c\beta$ after deducting 11·45 per cent of impurities. (*d.*) Another sample was decomposed by dilute hydrofluoric acid; the analysis was unfortunately lost excepting the determinations given below; the material for this analysis had not been dried over sulphuric acid. (*e.*) This sample was dried over sulphuric acid for several weeks; a portion, which was decomposed by sulphuric acid, gave 5·37 per cent insoluble silicates, 0·23 per cent of gold and 43·24 per cent of silicic acid; the V_6O_{11} was determined by difference. The results given below were obtained by decomposing the mineral by fusion.

	a	*b*	*cα*	*cβ*	*d*	*e*
Insoluble silicates, quartz, gold, &c. =	[0·85]	----	11·45	----	8·91	[5·60]
SiO_2 =	47·69	47·82	43·46	48·60	----	46·81
Al_2O_3 =	14·10	12·60	10·52	11·76	----	15·78
FeO =	1·67	3·30	2·03	2·27	----	1·58
MgO =	2·00	2·43	1·74	1·95	----	2·31
CaO =	trace	trace	0·20	0·23	----	trace
Na_2O (trace Li_2O) =	0·19	0·33	0.30	0·34	5·96	0·60
K_2O =	7·59	8·03	5·35	5·98		8·89
V_6O_{11} =	22·02	21·36	20·50	22·92	----	20·16
Ignition =	4·96	5·13	5·32	5·95	6·34	3·87
	100·22	101·00	100·87	100·00		100·00

A mineral, very similar in composition and perhaps a compact impure variety of roscoelite is found associated with the scales. It has the appearance of a massive dark green chlorite or that of some varieties of serpentine. The analysis was made by fusion, &c., and gave:

SiO_2	= 46·09	Na_2O	= 0·18
Al_2O_3	= 17·46	K_2O	= 8·66
FeO	= 1·95	V_6O_{11}	= 17·53
MgO	= 2·18	Ignition	= 6·37
			100·42

2. *Psittacinite, a new hydrous vanadate of lead and copper.*

In a paper on American Tellurium and Bismuth minerals, read before the American Philosophical Society at the meeting of August 21st, 1874 (Proc. Am. Phil. Soc., xiv, 223–231), I mention, on the authority of Mr. P. Knabe, a siskin-green pulverulent mineral from the "Iron Rod Mine," Silver Star District, Montana, as a *new* "Tellurate of lead and copper." I had at that time no opportunity to examine into the merits of this mineral, having mislaid the small sample which he had sent me. On receiving a copy of my paper, Mr. Knabe furnished me with several specimens, which gave me a sufficient quantity of fair material for an analysis. A qualitative examination proved it to be a hydrous *vanadate* of lead and copper and *not a tellurate.*

When I communicated this result to Mr. Knabe he gave me an interesting account of how he fell into his error. At the Uncle Sam's Lode, in Highland District, occurs with the tetradymite a siskin-green mineral, which has not yet been analyzed, but which appears to be a tellurate. It looks exactly like the pulverulent variety of the psittacinite from the Iron Rod Mine. When Mr. K. dissolved the latter in hydrochloric acid, the evolution of chlorine indicated the presence of a higher oxide; the solution precipitated with an excess of ammonic sulphide gave sulphides of lead and copper and a filtrate which, on addition of an acid, gave a black precipitate—vanadic sulphide—which he mistook for tellurous sulphide.

Psittacinite occurs in very thin cryptocrystalline coatings, sometimes showing a small mammillary or botryoidal structure, also pulverulent; color siskin-green, sometimes with a grayish tint, to olive-green. Before the blowpipe it fuses easily to a black shining mass. With fluxes gives the reactions of vanadium, lead and copper. Soluble in dilute nitric acid, the solution yielding on evaporation a deep red mass.

As it was impossible to get any of the mineral in a pure state, I had to use coatings with quartz attached to them, sometimes contaminated with a little limonite; but these admixtures

could not influence the analysis farther than very slightly with reference to the amount of water which it contains.

The following are my results:

		a	*b*	*c*	*d*	*e*
PbO	=	41·36	50·17	42·89	27·12	42·38
CuO	=	14·34	16·66	14·72	9·75	15·03
V_2O_5	=	14·64	19·05	15·87	9·96	15·77
H_2O	=	7·42		not determined	----	7·25
SiO_2	=	15·13		10·10		15·57
Al_2O_3	=	1·29		3·83		
Fe_2O_3	=	2·72	7·60	2·19	48·84	4·00
MgO	=	not det.		0·65		
CaO	=			0·15		

The oxygen ratio of PbO : CuO : V_2O_5 : H_2O in the above analyses is in:

a	=	2·97	:	2·89	:	6·41	:	6·59
b	=	3·60	:	3·36	:	8·34	:	----
c	=	3·08	:	2·97	:	6·95	:	----
d	=	1·94	:	1·96	:	4·36	:	----
e	=	3·04	:	3·03	:	6·90	:	6·44
or *a*	=	1	:	0·97	:	2·16	:	2·19
b	=	1	:	0·93	:	2·31	:	----
c	=	1	:	0·97	:	2·26	:	----
d	=	1	:	1·01	:	2·25	:	----
e	=	1	:	1	:	2·27	:	2·12

The average of the five analyses gives the ratio of

	1	:	0·98	:	2·25	:	2·15
	9	:	9	:	20	:	18

corresponding to—

$$3\,(3\,PbO, V_2O_5) + (3\,CuO, V_2O_5) + 6\,(CuO, H_2O) + 12\,H_2O.$$

giving the following percentage:

PbO	=	53·15
CuO	=	18·95
V_2O_5	=	19·32
H_2O	=	8·58
		100·00

Psittacinite occurs, sometimes associated with gold, and small quantities of cerussite, chalcopyrite and limonite upon quartz, at several of the mines in Silver Star District, Montana, especially in the Iron Rod Mine and New Career Mine, and its occurrence in these mines is looked upon as a favorable indication, for, when it is met with, the vein becomes immediately or soon after rich in gold. This mineral has been called "psittacinite" from psittacinus, siskin- or rather parrot-green.

University of Pennsylvania, Philadelphia, May 16th, 1867.

ART. VI.—*On a Disease of Olive and Orange Trees, occurring in California in the Spring and Summer of* 1875; by W. G. FARLOW, Assistant Professor of Botany in Harvard University.* With Plate III.

DURING the past summer, numerous complaints have come from southern California of a fungus which had attacked the olive and orange trees, and which was causing a considerable loss of those two crops. Our attention was first called to the subject by Dr. H. W. Harkness, who, in a letter from San Francisco dated May 11, sent a specimen of the fungus on an orange-leaf from southern California. Of the extent of the ravages of the fungus at that date no information has been received; but, as in a letter from San Diego, dated June 3, Mr. D. Cleveland† wrote that there was no trace of the fungus in that vicinity, we may suppose that the disease first appeared not far from Santa Barbara, where we have definite knowledge of its occurrence, and where great damage was done later in the summer. In a letter from Dr. George Thurber dated September 20, enclosing some specimens of the fungus, is the following from a correspondent in Santa Barbara: "We are troubled with our olive, lemon and orange trees. A small fungus appears on the leaves, twigs, and branches, at first visible only with a microscope, and of a green color. As it increases in size it turns brown, and then black. The olive is so exhausted that it is unable to fruit. The orange and lemon stand it better, but their fruit is so inferior as to be practically worthless." On the day of the receipt of Dr. Thurber's letter, another was received from Professor Dana, also enclosing specimens from Santa Barbara.

From the general tenor of letters from California, it is evident that, if this is not the first year of the appearance of the disease, it is, at least, the first in which it has attracted general attention; that its effect on the olive and orange crops has not been slightly, but markedly injurious; and that, in its advanced stages, there is present on the leaves and stems a blackish substance, which is universally regarded, by those who have formed any opinion on the subject, as a fungus. We have received, at different times, from California specimens of leaves and stems of orange and olive trees covered with the black growth, and have been able to study the fungus, which presents some points not without interest in a botanical point of view; and, if our conclusions do not point to a direct remedy, it will be conceded, we hope, that we have contributed toward removing some mis-

* Copied from the Bulletin of the Bussy Institution.

† We are in receipt of a letter from Mr. Cleveland, dated early in January, 1876, in which he sends specimens of the fungus on orange-leaves, which, he writes, is at that time common at San Diego.

conceptions as to the nature of the disease. At this distance, remote from all opportunities of observing the disease on living trees, there are, of course, some points in the development of the fungus which we have not been able to study; and our correspondence has not been sufficiently extensive or minute to enable us to give any statistics of the ravages of the disease, to ascertain the climatic or other changes which have preceded or accompanied the breaking out of the epidemic, or to decide whether it is the same form of disease which has been reported to occur in Florida. Our specimens present the disease as it appears when in a somewhat advanced stage, and after the leaves and stems have become so changed as to attract attention.

Mycelium.—The leaves of the olives which are affected by the disease are somewhat curled and shrivelled, and are of a browner color than normal leaves which have been gathered but a few weeks. On both surfaces of specimens sent us are black spots of greater or less extent, but in no case is the leaf perfectly black. On the upper surface the black spots are more numerous, more distinct in outline, and harder in substance, than on the lower, where they were more diffuse and of a powdery consistence. The twigs, of which we received only small specimens, are covered with spots which resemble more closely those on the upper than on the lower surface of the leaves. In one specimen the spots are nearly confluent, and the bark is visible in only a few places. After the leaves or stems have been soaked in water for a short time, the black substance can be scraped off without the least trouble, leaving the bark tolerably clean. The black substance, when seen with a magnifying power of four hundred diameters, is found to be composed of the stellate hairs peculiar to the olive, over which is growing a fungus, to the dark color of whose mycelium the spots owe their color. The mycelium is very variable in appearance. As a rule, it is composed of moniliform hyphæ, whose cells are ·006 mm. by ·008 mm., and in some places almost spherical. The color of the cell-wall is a dark or purplish brown, and in most of the cells there is a comparatively large-sized oil globule. These hyphæ branch in all directions, and the cells of the branches grow constantly longer, narrower, and paler, although, in all cases, retaining a tinge of brown. The relation of the mycelium to the stellate hairs and outer part of the twigs and leaves is clearly seen in cross sections. The hyphæ run along the surface of the epidermis and of the hairs, which it will be remembered resemble a broadly-opened, short-handled parasol. They are twined closely round the stems of the hairs, so closely, that the fungus cannot be removed without tearing them off. They do not enter into the cells of the olive, and there are no haustoria as in the case of some of the leaf parasites belonging

to the *Erysiphei*. Occasionally there are little knob-like projections of the cells which seem to indicate haustoria; but, by the most careful examination which we have been able to make, we have not been able to see that they enter into the cells of the stellate hairs or epidermis and act like haustoria. The surface of the hairs and epidermis, however, seems covered with a sticky substance (of which we shall have more to say hereafter), to which the hyphæ closely adhere. Plate 3, Fig. 2, shows one of the stellate hairs seen from below, with a portion of the mycelium growing upon it.

Various modifications of the mycelium are found principally on that portion growing on the outer part of the stellate hairs exposed to the air. After reaching a certain stage of development, they grow together in such a way that the hyphæ coming together laterally form a sort of membrane, as shown in Plate 3, Fig. 1, *d*. This membrane is composed of only one thickness of cells, but is very uneven as it follows and conforms to the inequalities of the hairs. Its general direction is parallel to the surface of the leaf or stem on which it is found.

Conidia.—The hyphæ, at their free ends, branch in all directions, and bear reproductive bodies of several kinds. The simplest form is that shown in Plate 3, Fig. 3, *d*, where the ordinary cells of the mycelium divide by cross partitions into two parts, which do not respectively grow to the same shape as the mother cell, but remain together two by two, as shown in the figure; the hypha becoming zigzag by the alternate lateral displacement of the pairs of cells, which finally drop off and readily germinate, each cell producing a germinal tube. In other parts of the mycelium, the terminal cell of certain threads divides by means of partitions, parallel to and at right angles to the axis of the filament, until a compound body is formed, which resembles the spores of the so-called genus Macrosporium. These bodies, which can only be described as irregular conglomerations of cells of an oval outline, are produced in great abundance and average ·015 mm. by ·025 mm., but are often much larger, though often smaller. They easily drop from their attachments and germinate, each cell being capable of producing a germinal tube. Other hyphæ, rising at right angles to the plane of the membranous portion of the mycelium, grow more and more attenuated, and branch at the tip; the terminal cells divide in two, as in Plate 3, Fig. 3, *c*, fall from their attachment, and germinate. This last modification of the hyphæ, which is by no means so common as the two previously described, will be recognized as corresponding to the so-called genus Helminthosporium, or Cladosporium, if we examine before the terminal cells have divided. It is out of the question to give specific names to such forms as those just described, which, since the

publication of Tulasne's "Carpologia Fungorum," are known to be different states of development of species of Pyrenomycetes.

Pycnidia.—Besides the forms already described, there are other bodies of a more complicated nature. Plate 3, Fig. 3, *a*, *a*, represents the *pycnidia*, which are quite numerous in the spots, both on the leaves and the stems. Their general shape is spheroidal. They consist of a membranous sac of the same color as the darker parts of the mycelium, in which are contained the small bodies, which are represented as being discharged in Fig. 3, *b*. Their average diameter is ·04 mm. In general appearance, the pycnidia resemble so closely those with which every one is familiar in other Pyrenomycetes, that any further description is unnecessary.

Stylospores.—In examining the larger black spots on the stems of the olive, other bodies are seen,—the *stylospores*, to adopt Tulasne's nomenclature. They are represented in Fig. 1, *a*, and resemble flasks, whose long necks project beyond the mycelium, by which they are surrounded. They may be recognized by the naked eye, and clearly seen with a hand-lens, as the black projecting necks are tolerably conspicuous. To obtain a good view of them, some of the larger black spots must be picked to pieces, and the fragments treated with caustic potash, and afterwards hydrochloric acid. The shape of the separate flasks is quite variable. The central portion of Fig. 1 represents one of the more regular, where, starting from a somewhat contracted base, there is a regular swelling of the central portion, which again diminishes into a rather long neck of uniform size. In some cases, the flask, instead of being straight, is flexuous with two swellings, the upper one being smaller than the lower. Others, still, fork, and usually one branch is much more obtuse than the other. The size of the flasks varies very much; but, even in their younger states, they can generally be distinguished from the pycnidia by being less inclined to a spherical shape. The height is as variable as the outline. Some of the smaller are ·15 mm. high; others—and they are nearer the average—are ·4 mm. The wall of the flasks is composed of dark-colored cells, which are longer in the direction of the axis of the flasks.

In some cases, the cells, composing the wall of the stylospores, grow outward, so as to form papillæ; and, as the mycelium at the base generally sends up branches around the flask, it is only by a careful dissection that the base can be clearly seen. At first, the mouth is closed, and there is a depression of the cells at the center; but, later, they spring back so as to form, round the open mouth, a circle of slightly reflexed teeth, whose tips are perfectly hyaline. The neck of the flask is hollow: but, in the swollen portion, spores are borne. They are oval, and divided

into four parts by cross partitions. They are not contained in asci, but are attached to short filaments which line the surface of the base and lower portion of the sides of the flask. They escape readily through the open mouth; and slight pressure on the covering-glass generally causes a fresh discharge.

So far, we have spoken of the fungus as seen on the olive. The orange-leaves sent us are also covered with a black substance, which is not so much in spots as in powdery sheets upon both surfaces of the leaves, more particularly the upper. The attachment to the leaf is by no means as strong as in the olive; and the deposit can easily be scraped off, even without previous moistening. In fact, in some places it falls off on the slightest touch. No specimens of diseased orange-stems were received for examination. A microscopic examination shows why the deposit was more easily removed from the orange than the olive leaves. The smooth surface of the former gives no permanent attachment to the fungus, which, as we have before said, does not penetrate into the interior of the cells of the mother plant; while, on the other hand, the hyphæ wind themselves tightly around the stalks of the stellate hairs of the olive, from which they cannot be removed. If the fungus should attack both oranges and olives, it is very evident why the latter would suffer much more than the former. Apart from the absence of hairs, which invariably constitute a large proportion of the scrapings of the olive-leaves, that from the orange-leaves is precisely identical,—the same moniliform hyphæ, bearing Macrosporium and Helminthosporium spore-like bodies, the same pycnidia and stylospores. Micrometric measurements only confirm the identity. On the orange-leaves sent me, there is a greater proportion of pycnidia, and a smaller proportion of stylospores, than in case of the olive-leaves; but that is, of course, an accidental difference, as the olive-leaves themselves vary. On the orange, the proportion of Helminthosporium-like spores is much greater than on the olive; but, from the facility with which the so-called secondary forms of fruit are produced in fungi, and their great variability, that it is not a fact of any importance; and we can in the most decided manner affirm that the fungus is the same on both plants.

The first account of a fungus growing upon orange-trees, resembling in its habits that received from California, was given by Persoon, in his Mycologia Europæa, p. 10, published in 1822. His description of the new fungus is very briefly given in the following words: "Fumago Citri, late effusa crassiuscula nigro-grisea. Provenit in Europa meridionali ad folia Citri Medicæ, quæ sæpe tota induit." Later, Turpin published an account, with a figure, of a species which he also called Fumago Citri, which Montagne made the type of a new genus, Capnodium,

published in the Annales des Sciences Naturelles, 3 série, tome 11, 1840. Montagne seems to have had doubts as to the identity of the Fumago Citri of Persoon with that of Turpin. Almost simultaneously with the publication by Montagne of his genus Capnodium, Berkeley and Desmazières published, in the Journal of the Horticultural Society of London, vol. iv, p. 252, an article "On some Moulds referred by Authors to Fumago." In this communication, there is the following description of the orange fungus briefly referred to by Persoon and Montagne: "Capnodium Citri, Berk. and Desm. Sparsum, setosum; peridiis elongatis; mycelio ramoso moniliformi pulcherrime reticulato; sporidiis oblongis minutis. Fumago Citri, Pers., Myc. Eur., vol. i, p. 10; Turpin, l. c. On leaves of different species of Citrus. France: Persoon, Léveillé."

Of fungi occurring on olive trees, we have an early account by Montagne in the Annales des Sciences Naturelles, 3 série, tome 12, 1849, of a fungus mentioned in the "Bull. Soc. Centr. d'Agric.," 2 série, iv, p. 267, under the name of Antennaria elæophila, which had been found at Perpignan in 1829, which caused ravages somewhat the same as the California fungus, and which had previously been referred by him to Cladosporium Fumago. It was probably the same plant as the Torula Oleæ of Castagne. Tulasne, however, in the "Carpologia Fungorum," vol. ii, p. 279, showed that the Freiesian genus Antennaria was the pycnidial state of species of fungi of which Capnodium was the ascigerous state. He restored the old name, Fumago, and gave a detailed account of Fumago salicina, which was illustrated in his unrivalled manner.

The fungus from California is evidently the same as that which has been known in Europe since 1829. We have examined two authentic specimens of Antennaria elæophila Mont.,—one from the Duby Herbarium, the other from that of De Notaris, and the structure is precisely that of the pycnidial-bearing portion of the California fungus. The stylospore-bearing portion of our fungus is the Capnodium Citri of Berkeley and Desmazières, to which they refer the Fumago Citri of Persoon and Turpin. Montagne had observed only the pycnidial form—his Antennaria elæophila—on olives; whereas, on the orange, he found only the stylospore form,—his Capnodium Citri. Berkeley and Desmazières make mention only of stylospores on species of Citrus. We have been so fortunate as to find, on the specimens from California, both pycnidia and stylospores, and on both olives and oranges,—which proves the identity of Antennaria elæophila (Mont) and Capnodium Citri (Berk. and Desm.) The perfect ascigerous state of the fungus we have not found; nor do Berkeley and Desmazières seem to have met with it, for they add to their description "asci have not been observed."

We have not been able to find any recorded instance of asci having been found in Capnodium Citri. Tulasne remarks,—quite pertinently, as it seems to us,—that, until better known, Capnodium Citri and Antennaria elæophila can scarcely be considered distinct from Fumago salicina.* The specimens from California certainly seem to strengthen Tulasne's suspicions; and we must confess ourselves quite unable to distinguish between Fumago salicina—found on willows, oaks, birches, hawthorn, quince, and pear—and Capnodium Citri, found on oranges, and, as the Californian specimens show, also on olives. If it be said that no asci have been seen by us, that is no reason why the fungus should be removed from Fumago salicina, which, in the conformation of its mycelium, its conidia, pycnidia, and stylospores, it most closely resembles. Evidently, in the group of fungi which we are considering, too much stress must not be laid on the length and shape of the stylospores. We see, in the specimens before us, how great is the variation in what is undoubtedly a single species. Neither is the fact of the branching of the stylospores very significant, as, in the present case, there are both simple and branching stylospores. If the reader will compare our Plate 3, Fig. 1, with that of *Fumago salicina*, by Tulasne, "Carp. Fung.," Plate XXXIV, Figs. 14 and 20,—leaving out of sight, as far as possible, the different artistic merits of the two,—we think he will admit that, in all essential particulars, they are alike. In reality, the resemblance is even greater than the limited size of our drawing would indicate. We have said that we found no asci; but Plate 1, Fig. 1, *c*, would seem to be the early stage figured by Tulasne, l. c. Fig. 20. The asci will probably be found in California; and we do not doubt that they and their contained spores will prove to be like those of Fumago salicina.

If we seem to the reader to have gone too minutely into the consideration of the systematic position of the fungus, it was for the purpose of bringing out more forcibly the fact that it is nothing new, or peculiar to California; and that it is not even limited to orange, lemon, and olive trees, but, as we have seen, is found on a number of other trees. How does it happen, then, that a fungus so widely diffused should suddenly increase to such an extent as to injure two important crops? We remarked, in passing, that the hyphæ seemed to be, as it were, gummed to the stellate hairs, and, in some cases, to one another, by a sticky substance. We do not forget, that, when any mycelium is growing on a leaf, a certain amount of dirt—including, of course, some oily matter—is sure to be entangled in its meshes. In the

* "Donec melius cognoscantur, a Fumagine salicicola supra descripta ægre etiam discriminantur, nisi sede sibi singulis assueta, tum *Fumago Citri*, Persoonio seu *Capnodium Citri* Montanio; tum etiam *Antennaria elæophila*, Montanio," &c. (Selecta Fungorum Carpologia, pp. 283, 284.)

case of the present fungus, however, there is something more than an accidental accretion of such substances. The surface of the leaves and stems is in many places covered with a gummy deposit, presumably of insect, certainly not of fungus, origin. On this gum, the fungus grows luxuriantly; and, although it may be found on those parts of the leaves where no gum can be seen, yet it is evident that it has reached such places by growing from the gummy spots. Of the origin of the gum, other than that it does not come from the fungus, we have no theory of our own to advance. Remains of insects are abundant on the leaves; but, being entirely ignorant of entomology, we cannot say what their relation is to the diseased trees. It may be that they are stray visitors caught in the gum. The fungus grows most luxuriantly on the remains of insects which I have seen, which, in some cases, present a ludicrous spectacle, the hyphæ projecting from them like the quills of a hedgehog.

It has often been asserted by botanists that fungi, of the group to which ours belongs, are particularly inclined to attack trees which have been previously infested with insects. In 1849, Berkeley, in the London Journal of Horticulture, described a fungus occurring in Ceylon on coffee,—*Triposporium Gardneri*,—which followed the appearance of a species of coccus which was described in the same journal by Mr. George Gardner. In their paper on moulds referred to Fumago, Berkeley and Desmazières make the following statement: "They are often, if not always, preceded by honey-dew, whether arising from aphides, or from a sugary excretion from the leaves themselves. Frequently, too, they are accompanied by some species of coccus, especially in the genus Citrus." Tulasne * does not agree with the writers just mentioned, as will be seen by the reference. He begins his description of Fumago salicina, however, with the following words: "Initio fungillus e membranula constat tenuissima, alba, et hyalina, matricique vivæ instar gummi soluti illitus hæret, quamvis ab eadem, maxime si fortuito ea aruerit, frustulatim aliquando secedat. Id cuticulæ struunt utriculi, perexigui, . . . oleo pallido tandem repleti," &c. This initial stage described by Tulasne is figured in Table XXXIV, Fig. 2, mm., l. c. We must confess that the expression "matricique vivæ instar gummi soluti illitus hæret," seems a little indefinite, but the figure looks

* Quibusdam observatoribus visum est *Fumagines* in fructicibus potissimum provenire quos aphides primum occupassent, tamquam si ex humore dulci quem bestiolæ istæ emittunt, aut ex latice viscido quem matrix ab iis læsa copiosum aliquando stillat, suum pabulum traherent; necessitates autem hujus modi duplici de causa minime verisimiles censemus. Hinc enim sexcenties nobis contigit *Fumagines* luxuriantes videre in arboribus, omnis aphidum generis prorsus expertibus; illinc *Fumagines* vere parasitari constat, succis scilicet alienis uti ex his vivis. Super hoc argumento conferas tamen quæ attulit Berkelæus in tomo iv. (1849) Ephemeridis Soc. Hortic. Londinensium, nec non Georgio Gardner commentatiunculam ibidem (pp. 1–6) editam circa the Coffee-bug and Coffee-mildew. (Carp. Fung., ii, p. 280.)

exceedingly like a collection of oil-globules, or very small eggs. We do not pretend to say that what Tulasne saw was not a membrane of vegetable substance,—a part of the fungus itself; but, in the Californian specimens, we had something which looked very much like the mm. of Tulasne's figure, and, in this case, we have satisfied ourselves, by observation and experiment, that it is of animal nature, and not a part of the fungus, which, instead, was growing upon it. It is a little difficult to understand, from what is already known of the developement of fungi, how any fungus could begin as a very thin membrane, composed of small cells filled with oil. The initial stage of fungi, if we except the Myxomycetes, as far as we know, is filamentous, not membranous.

The result of our examination of the diseased orange and olive leaves is briefly as follows: The disease, although first attracting the eye by the presence of a black fungus, is not caused by it, but rather by the attack of some insect, which itself deposits some gummy substance on the leaves and bark, or so wounds the tree as to cause some sticky exudation, on which the fungus especially thrives. It is not denied that the growth of the fungus greatly aggravates the trouble already existing, by so encasing the leaves as to prevent the action of the sunlight; we only say, that, in seeking a remedy, we are to look further back than the fungus itself,—to the insect, or whatever it may be, which has made the luxuriant growth of the fungus possible. With regard to the fungus, we are able to assert that it is the same on both olives and oranges,—the species described by Berkeley and Desmazières under the name of *Capnodium Citri*, which seems to us, together with the pycnidial state described by Montagne under the name of *Antennaria elæophila*, to be but two states of a species identical with that described by Tulasne as *Fumago salicina*. It remains yet to find the asci on olives or oranges, which will probably be accomplished without difficulty in California. The earliest stages of the fungus should be studied by some one living near orange groves; for, although the disease has been known to attack greenhouse plants, it is not very common, or, in that case, so favorable for study. Especially is it to be desired that careful notes of the extent and manner of appearance of the disease, and the climatic and hygrometric conditions attending it, should be carefully recorded.

As a remedy, alkaline soaps, as strong as the trees will bear, will no doubt prove advantageous in case of the oranges; but, in the case of the olives, much less good is to be expected, owing to the presence of the stellate hairs on leaves and twigs. With this, our notice of the disease from a botanical stand-point ends; and we commend the subject to the attention of entomologists.

ART. VII.—*On the Reaction of Sulphuric Acid upon Tri-calcic Phosphate;* by H. P. ARMSBY.

THE following experiments were undertaken to ascertain the influence of temperature and time on the reaction between one molecule of sulphuric acid and one of tri-calcic phosphate.

The materials employed were precipitated tri-calcic phosphate and a solution of sulphuric acid containing in 1 c.c., 0·8784 grms. H_2SO_4.

The tri-calcic phosphate was prepared by precipitation from an ammoniacal solution of calcium chloride by di-sodic phosphate, the precipitate being washed with cold water. An analysis gave:—

Ca	33·73 per cent.
PO_4	53·82 " "
H_2O	not determined.

Although washed by decantation till the washings gave no precipitate with silver nitrate the substance still contained traces of soluble phosphoric acid, probably as phosphate of soda.

The experiments were conducted as follows: a weighed quantity (generally about five grms.) of tri-calcic phosphate was mixed by rubbing in a mortar with the equivalent quantity of sulphuric acid, and treated as follows:—

I.	Stood 2½ hours at 100° C.
II.	" " " " ordinary temperature.
III.	" " " " " "
IV.	" ½ hour " " "
V.	" 5 minutes at " "

The mixture was then washed with cold water till the washings ceased to show an acid reaction, the filtrate diluted to 500 c.c. and in it lime, phosphoric acid, and sulphuric acid determined. The composition of the insoluble portion was in some cases determined directly, and in others by difference. In calculating the results, the sulphuric acid of the aqueous solution was combined with lime, the residue of the lime with phosphoric acid to mono-calcic phosphate, and the remainder of the phosphoric acid was considered as free. A portion of it at least may have been the soluble phosphoric acid of the tri-calcic phosphate. In the insoluble portion the sulphuric acid was also combined with lime, and the remainder of the lime with phosphoric acid, the excess of the latter over that required to form tri-calcic phosphate being considered to exist as the only other insoluble compound, viz., di-calcic phosphate. The following table gives the results calculated on ten grams of $Ca_3(PO_4)_2$.

APPLIED.	I.	II.	III.	IV.	V.
$Ca_3(PO_4)_2$	10·000 grms.	10·000 grms.	10·000 grms.	10·000 grms.	10·000 grms.
H_2SO_4	3·143 "	3·748 "	3·209 "	3·209 "	3·209 "
FOUND, soluble.					
$CaSO_4$	2·124 grms.	2·459 grms.	2·960 "	1·140 grms.	
$CaH_4(PO_4)_2$	·837 "	1·277 "	1·334 "	·850 "	3·562 grms.
H_3PO_4	·309 "	·343 "	·152 "	·448 "	
Insoluble.					
$CaSO_4$	2·168 grms.	2·784 grms.	1·504 grms.	3·466 "	
$CaHPO_4$	6·467 "	6·120 "	5·415 "	5·493 "	
$Ca_3(PO_4)_2$	1·065 "	·803 "	1·899 "	1·947 "	

It will be seen that the amount of di-calcic phosphate increases and that of mono-calcic phosphate decreases the longer the mixture stands and the higher the temperature to which it is exposed.

The following table shows the decrease of mono-calcic phosphate still more clearly.

If the reaction take place according to the equation

$$Ca_3(PO_4)_2 + 2H_2SO_4 = CaH_4(PO_4)_2 + 2CaSO_4$$

one molecule of sulphuric acid should render soluble one molecule, or its own weight, of phosphoric acid. The fourth line of the table gives the per cent of this theoretical quantity which was actually found.

	I.	II.	III.	IV.	V.
Applied, $Ca_3(PO_4)_2$	2·784 grms.	2·972 grms.	4·377 grms.	4·377 grms.	4·377 grms.
" H_2SO_4	·875 "	1·113 "	1·405 "	1·405 "	1·405 "
Found H_3PO_4	·282 "	·420 "	·555 "	·507 "	1·305 "
% of theoret. H_3PO_4	32·2 %	37·7 %	39·5 %	36·1 %	92·8 %

In order to be sure that these differences were not due to incomplete washing a second set of experiments was made with smaller quantities. The tri-calcic phosphate was mixed with water to a thin paste, the sulphuric acid added, the mixture well stirred, and treated as follows:—

I. Stood 3 hours at 100° C.
II. " " " " ordinary temperature.
III. " ½ hour " " "
IV. " 5 minutes at " "

It was then filtered on the pump, washed with cold water till the washings showed only a very faint reaction for phosphoric acid with magnesia mixture, the filtrate diluted to 500 c.c. and in 50 c.c. the phosphoric acid determined by the molybdic method.

	I.	II.	III.	IV.
Applied, $Ca_3(PO_4)_2$	1·751 grms.	1·751 grms.	1·751 grms.	1·751 grms.
" H_2SO_4	·438 "	·438 "	·438 "	·438 "
Found, H_3PO_4	·172 "	·200 "	·209 "	·415 "
% of the theoretical H_3PO_4	39·2 %	45·6 %	47·7 %	94·7 %

To ascertain the extent of error from incomplete washing the insoluble portion of I. was further washed with about 250 c.c. of cold water and the phosphoric acid in the filtrate determined. Its amount was 0·013 grms. a part of which was doubtless due to di-calcic phosphate which is slightly soluble in water, though not sufficiently so to introduce any material error into the experiments.

From the above results it appears that the reaction between sulphuric acid and tri-calcic phosphate, when the two are present in the proportion of one molecule of each, passes through two stages.

1st. The sulphuric acid reacts on half the tri-calcic phosphate, producing mono-calcic phosphate. Whether free phosphoric acid is at first produced cannot be determined from these experiments, but if it is, it must quickly disappear.

2d. The mono-calcic phosphate thus produced reacts more slowly on the other half of the tri-calcic phosphate in the manner described by Piccard (Zeitschr. für Chemie, ix, 545), producing di-calcic phosphate,

$$CaH_4(PO_4)_2 + Ca_3(PO_4)_2 = 4CaHPO_4.$$

A high temperature appears to favor the reaction.

Chemical Laboratory of the University of Leipzig, March, 1876.

Art. VIII.—*Dr. Vogel's Color Theory;* by M. Carey Lea, Philadelphia.

When Dr. Vogel first endeavored to establish the existence of a relation between the color of substances modifying the sensitiveness of silver bromide and the refrangibility of the rays to which that sensitiveness was increased, I made a two-fold objection. First, that no sufficient proof had been given that in any one instance a colored pigment had increased the sensitiveness to the rays which it absorbed. Second, that many substances altogether colorless conspicuously increased the sensitiveness to particular rays. To this last objection Dr. Vogel replied that because substances were colorless, it did not follow that they acted equally upon the different rays.

To give this answer weight, it should have been accompa-

nied by proof that some of these colorless substances showed a power of absorbing the rays to which they increased the sensitiveness of silver bromide. No such proof was given. Although scarcely called upon to prove a negative, yet desiring to leave no side of this question unexamined, I have recently subjected to careful spectroscopic examination those colorless substances which I have described as distinctly increasing the sensitiveness of silver bromide to green light.

This examination was made with a table spectroscope furnished with an exterior prism to throw light from a second source of illumination upon the slit, in order to obtain two adjacent spectra. The solution being then interposed in the path of one set of rays, the spectrum influenced by it is seen side by side with a complete spectrum, and the slightest changes are made evident. For greater exactness the glass vessel was first filled with water and interposed, then the argand burners used were moved to such distances as to make the two spectra exactly equal in intensity. In the examination, the size of the slit was varied from that which barely gave a visible spectrum, up to such as gave a powerful illumination, and the comparison was made with all intensities, though of course the faint illuminations gave the most critical tests. The substances examined were potassic arsenite, codeia, salicine and morphia acetate. All of these substances, as I have elsewhere shown, exhibit a marked power of increasing the sensitiveness of silver bromide to the green rays.

No elective absorption could be detected in any of them. It is therefore certain that *their capacity to increase the action of the green ray is independent of any power to absorb that ray.*

Certainly if a law such as enunciated by Dr. Vogel existed, there ought to be found, without difficulty, very many substances which would exemplify it. On the contrary Dr. Vogel has named very few cases in which he has recorded results conforming to his hypothesis. Indeed his hypothesis has seemed to rest chiefly upon three substances, coralline, chlorophyll, and naphthaline red.

I have very carefully examined the action of all three of the substances with the following results:

Coralline, as I have before said, enhances the sensitiveness more to the color which it chiefly transmits, red, than to those which it absorbs. Moreover its power of increasing sensitiveness (at least as far as the green rays are concerned) may be destroyed by the addition of a trace of weak acid, so that while its color remains, its action is destroyed. Coralline therefore does not afford any support to the theory, but rather the contrary.

Chlorophyll is perhaps the only substance that corresponds to some extent in its action with the demand of the theory. Some chlorophyll, which I prepared from ivy leaves, had a bright green color in solution; it diminished the action of silver bromide to the green rays, and increased it to the red. It should be said however that the support given by this substance is very much qualified by its peculiar absorption spectrum.

Naphthaline red has been cited by Dr. Vogel as affording by its action a powerful confirmation of his views. It has not done so in my hands.

When a not too strong solution is examined in the spectroscope, it is found to allow all the red and yellow rays to pass up to the limit of the green, where the transmission stops. Dr. Vogel affirms that the naphthaline red increases sensitiveness to the *yellow* rays, using it in not too strong solution. But it is certain that this substance unless it is used in very strong solution, allows the yellow rays to pass freely, stopping only the green and the rays beyond the green. It appears, therefore, that a dilute solution of naphthaline red *does not absorb* the yellows rays, to which, according to Dr. Vogel, it increases sensitiveness. And again the result of experiments made by myself with the green rays, which it does undoubtedly absorb, is that it not only does not increase sensitiveness to them, but actually diminishes it.

I therefore conclude that up to the present time no proof of the correctness of this theory has been found, but, on the contrary, a vast array of facts that are irreconcilable with it.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the true Ethyl Sulphate.*—By acting on ethyl alcohol or ether by sulphuric acid, Wetherill obtained a neutral body which has been regarded since that time as the true sulphuric ether, $SO_2 \left\{ \begin{matrix} OC_2H_5 \\ OC_2H_5 \end{matrix} \right.$. Later Baumstark obtained a substance by acting on alcohol by sulphuric oxychloride, which he supposed identical with Wetherill's ether, but which Max Müller regarded as an isomer of it, ethyl oxyethansulphonate, $C_2H_4 \left\{ \begin{matrix} OH \\ SO_2OC_2H_5 \end{matrix} \right.$. Mazurowska has prepared anew this latter compound, and has examined it more thoroughly. It appears as a yellowish, odorless, neutral liquid, of syrupy consistence and having a sp. gr. of 1·24. It dissolves readily in water, decomposing and becoming acid. Heated above 100° it carbonizes. Analysis gave it the formula

$(C_2H_5)_2SO_4$. Decomposition by water gave sulphethylic acid, the barium and potassium salts being prepared and analyzed. Methyl, propyl, butyl, and amyl alcohols yielded similar ethers, having analogous properties and forming a regular series. Wetherill's ether, however, is markedly different in its properties. It is an oily, colorless liquid, with an odor like peppermint, of sp. gr. 1·12, and which can be distilled, oily drops passing over at 110° to 120°. To ascertain which of these bodies was the true ether, the ethers themselves as well as the acids derived from them, were treated with potassium sulphydrate. In this way, Baumstark's body was proved to be the true ethyl sulphate, Wetherill's being its isomer as above. Similar ethers were obtained with phenol, nitro-phenol and thymol.—*J. pr. Ch.*, II, xiii, 158, March, 1876. G. F. B.

2. *Anthraflavic and Isoanthraflavic acids.*—Schunk and Roemer have detected in crude artificial alizarin a new acid, isomeric with anthraflavic acid discovered by the former chemist in 1871. To obtain it the crude alizarin is treated with lime water and the red solution decomposed with hydrochloric acid. The precipitate is dissolved in dilute soda solution, again precipitated, dissolved in baryta water, and thrown down a third time. The yellow or green flocks crystallize from alcohol in yellow needles, sometimes in gold-yellow brilliant plates. Analysis of the substance dried at 150° gave the formula $C_{14}H_8O_4$; the crystals have a molecule of water. The salts of the new acid were prepared and analyzed, and compared with those of anthraflavic acid. These as well as the substitution derivatives showed marked differences between the two bodies. Both, it should be remembered, are isomeric with alizarin.—*Ber. Berl. Chem. Ges.*, ix, 378, March, 1876. G. F. B.

3. *On Sulphonaphthalide.*—Cleve has examined the substance obtained by Berzelius in 1837 by the action of sulphuric acid on naphthalene, and which he called sulphonaphthalide. Crystallized from absolute alcohol, it appears in perfectly white needles, often some centimeters long. It melts at 175·5°, is insoluble in water, difficultly so in alcohol and ether, very soluble in benzene. Analysis gives it the formula $C_{20}H_{14}SO_2$, or $SO_2\left\{\begin{matrix}C_{10}H_7\\C_{10}H_7\end{matrix}\right.$. Heated with phosphoric chloride and with ammonia, it yields a mixture from which ether extracts a solid body β-chloronaphthalene, $C_{10}H_7Cl$, leaving, behind the amide of β-naphthylsulphurous acid, the chloride being $C_{10}H_7SO_2Cl$.—*Bull. Soc. Ch.*, II, xxv, 256, March, 1876. G. F. B.

4. *Evolution of Hydrogen by the action of Zinc upon neutral Copper sulphate.*—For the preparation of a considerable quantity of finely divided copper by Schiff's method, Lothar Meyer heated to 60° C. a mixture of copper sulphate crystals, metallic zinc and water, and observed a rapid evolution of pure hydrogen, a fact noted in 1840 by Leykauf. Further experiments showed that the evolution of hydrogen takes place at ordinary tempera-

tures, but is very slow, continuing for months. The resulting solution contains only normal zinc sulphate, no basic salt being present. A dark gray powder is deposited, however, which consists of basic zinc sulphate and copper. It appears therefore that the copper in this reaction is not simply exchanged for zinc, atom for atom, but that some of the copper is replaced by hydrogen. This, giving hydrogen sulphate, is acted on by the zinc, evolving hydrogen.—*Ber. Berl. Chem. Ges.*, ix, 512, April, 1876. G. F. B.

5. *Decomposition of Ammonium nitrate by heat.*—BERTHELOT has studied the decomposition of ammonium nitrate by heat. He finds that this salt melts at about 152° C., but that no appreciable quantity of gas is evolved below 210°. The rapidity of the evolution increases uniformly with the rise in temperature up to 300°, and then, if the fire be urged, the mass explodes. These characters are those of an exothermic decomposition and sustain the results of the author's calorimetrical experiments, according to which the production of the hyponitrous oxide theoretically disengages, in the reaction $NH_4NO_3 = N_2O + (H_2O)_2$, about +46 calories. The volume of gas obtained, however, is always less than that indicated by theory, owing to the volatility of the ammonium nitrate itself. Indeed this salt may even be sublimed without decomposition by placing it, previously melted, in a capsule covered with paper, and over which is a card-board cylinder filled with fragments of glass. The capsule is placed in a sand bath and heated to 190° to 200°; the sublimed salt attaches itself in brilliant crystals to the sides of the capsule and the paper cover, a portion also passing through and covering the glass. Its composition was verified by analysis. That this is not a dissociation into ammonia and nitric acid is shown by the fact that the paper is not attacked.—*C. R.*, lxxxii, 932, April, 1876. G. F. B.

6. *Additional facts concerning Gallium.*—BOISBAUDRAN, the discoverer of gallium, has presented to the Academy a specimen of what he believes to be the nearly pure metal. The specimen weighed about one decigram and was extracted from 431 kilograms of the crude material. Unlike the specimen first made, and which was solid owing to impurities, the author finds pure gallium to be essentially a liquid metal, since it melts at 29·5°, and is therefore easily liquefied between the fingers. It exhibits markedly the phenomenon of surfusion, a globule remaining liquid for weeks, during which time the thermometer may go down to zero. Once solidified, the metal is hard and resistant; though easily cut and somewhat malleable. When melted it adheres strongly to glass forming a whiter mirror than mercury. Heated to redness in the air, it oxidizes only superficially and does not volatilize. It is not sensibly attacked by cold nitric acid. Its density is 4·7 at 15°. Deposited on platinum by electrolysis from solution in ammonium or potassium hydrate, it presents a grayish-white mat surface, formed of minute globules. Cold dilute hydrochloric acid dissolves it, disengaging hydrogen; but the residue obtained by evaporating this solution, is not colored by potassium

iodide, ammonia, or ammonium sulphydrate.—*C. R.*, lxxxii, 1036, May, 1876. G. F. B.

7. *Metallic Cerium, Lanthanum, and Didymium.*—Drs. HILLEBRAND and NORTON, in Bunsen's laboratory, have obtained, by the electrolysis of the cerium, lanthanum and didymium chlorides, the metals in quantities sufficient for careful investigation. As proof of the purity of the materials employed they refer to the methods of separation given by Bunsen (Pogg. Ann., clv, 366). Metallic cerium has the color and luster of iron; it slowly tarnishes in dry air and in moist air soon changes color, as steel does when heated, to yellow, blue, and gray. After fusion it has the hardness of calcite, and is malleable and very ductile. The specific gravity of the electrolytic metal is 6·628, and after fusion under salt and potassium chloride it is 6·728. The low specific gravity found for cerium reduced by sodium 5·5 indicates that it contained sodium. The melting point of cerium is lower than that of silver and considerably higher than that of antimony. Its kindling temperature in air and oxygen is much lower than that of magnesium. Pieces scratched off inflame, and the wire ignited in a flame burns more brilliantly than magnesium wire. It burns when heated in chlorine, less readily in bromine vapor, and without incandescence in iodine vapor. Water at common temperatures is slowly decomposed by it; cold concentrated sulphuric acid and cold red fuming nitric acid do not attack it, but these acids when dilute, and also hydrochloric acid, dissolve it. Metallic lanthanum is much like cerium in its general chemical deportment, but by concentrated nitric acid it is easily attacked. It is slightly harder and less ductile than cerium; it is less permanent in air, and even in dry air its color soon changes to a steel blue. The specific gravity of a piece deposited by electrolysis weighing 7·6 grams was 6·163; after fusion it was less, 6·049. Its melting point appears to be near that of cerium, and its kindling temperature is higher. Small pieces from filing or striking on flint do not ignite spontaneously in the air, but burn brilliantly in the flame. Their analysis shows less than one per cent of impurity in the specimen.

Metallic didymium is more like lanthanum than cerium; it is not less lustrous, ductile or permanent in air than lanthanum, and has about the same hardness; its color is not as white, and moist air turns it yellow. Fine particles of the metal do not ignite spontaneously in the air, but burn when heated in a lamp flame. It is less fusible than either lanthanum or cerium, and the metal after fusion has a specific gravity of 6·544.—*Pogg. Ann.*, clv, 633, Aug., 1875. G. F. B.

8. *On Gentisin.*—HLASIWETZ and HABERMANN have published a second paper on Gentisin, a crystallized non-nitrogenous body obtained from gentian root (*Gentiana lutea*). In their previous paper they showed that under the influence of alkali hydrates, gentisin splits up into phloroglucin $C_6H_6O_3$ and an acid of the formula $C_7H_6O_4$, to which they gave the name gentisic acid.

Under the action of heat, this latter body loses carbon dioxide and yields a neutral body of the composition $C_6H_6O_2$, provisionally called pyrogentisic acid. They now find that this last substance is identical with hydroquinone, the true melting point of which is 169°, and that gentisic acid is identical with oxysalicylic acid, which fuses at 196° to 197°. From its reactions therefore the authors give to gentisin the rational formula

$$\begin{matrix} C_6H_2\left\{\begin{matrix} CH_3 \\ O \\ O \end{matrix}\right. \\ | \\ CO \\ | \\ C_6H_3\left\{\begin{matrix} OH \\ OH \end{matrix}\right. \end{matrix}$$

and suppose that it is formed from an isomer of piperonal united to phloroglucin, thus:

$$C_6H_2\left\{\begin{matrix} CH_3 \\ O \\ O \\ CO\,H \end{matrix}\right. + C_6H_3\left\{\begin{matrix} OH \\ OH \\ OH \end{matrix}\right. - H_2O = \begin{matrix} C_6H_2\left\{\begin{matrix} CH_3 \\ O \\ O \end{matrix}\right. \\ | \\ CO \\ | \\ C_6H_3\left\{\begin{matrix} OH \\ OH \end{matrix}\right. \end{matrix}$$

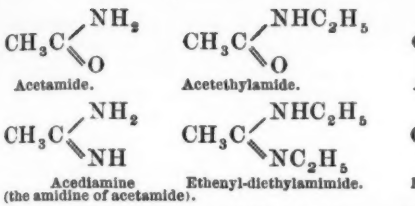
Hence when it is fused with alkalies, it acts thus:—

$$\underset{\text{Gentisin.}}{(C_{14}H_{10}O_5)_2} + O_2 + (H_2O)_4 = \underset{\text{Phloroglucin.}}{(C_6H_6O_3)_2} + \underset{\text{Oxysalicylic acid.}}{(C_7H_6O_4)_2} + \underset{\text{Acetic acid.}}{C_2H_4O_2}$$

—*Liebig's Annalen*, clxxx, 343, March, 1876. G. F. R.

9. *On the milky juice of an Asclepiad, Cynanchum acutum.*—Butlerow has examined the milky juice of Cynanchum acutum, brought from the Oxus by the Russian Geographical Society's Expedition. The plant is a climber and is regarded as poisonous, especially to camels. The juice contained a volatile non-poisonous alkaloid, and the aqueous portion was rich in potassium chloride, but contained no sodium though grown on a soil rich in that substance. Below the aqueous portion was a white coagulum, which fused by heat and evolved an odor like that from burning rubber. It was extracted with boiling alcohol and then with carbon disulphide. The latter left on evaporation a transparent yellow resin. The alcoholic solution deposited warty grains on cooling, which when purified crystallized in needles. On analysis this body gave the formula $C_{15}H_{24}O$, and as it appears analogous to the phenols in its properties, the author gives it the name cynanchol; the asclepion of List being an impure variety.—*Liebig's Ann.*, clxxx, 349, March, 1876. G. F. B.

10. *On Amidines of Monobasic Acids.*—The name amidine was given first by Wallach to a class of organic bases of the general formula $R.C\left\{\begin{matrix} NR'' \\ NR'_2 \end{matrix}\right.$ derived from amides $R.C\left\{\begin{matrix} O \\ NR'_2 \end{matrix}\right.$ by exchanging O for $(NR)''$. As R represents either hydrogen or a hydrocarbon radical, it is evident that a series of bases may be formed from the amide of any acid in this way. Thus from acetamide



we have

In the same way, guanidine is the amidine of carbamide or urea. Under the influence of water the acid amides are regenerated. BERNTHSEN has examined several new bodies of this class, phenyl-acetamimide $C_6H_5-CH_2-C\begin{matrix}NH_2\\ \diagdown\!\!\diagup\\ NH\end{matrix}$, its mono-phenyl and mono-tolyl derivatives, benzenyl-monophenyl-amimide,

$$C_6H_5-C\begin{matrix}NH_2\\ \diagdown\!\!\diagup\\ NC_6H_5\end{matrix},$$

and the diphenyl, mono- and di-tolyl derivatives.—*Ber. Berl. Chem. Ges.*, viii, 1575; ix, 429, March, 1876. G. F. B.

11. *On Fermentation;* by P. SCHÜTZENBERGER. [International Scientific Series. D. Appleton & Co., New York.]—This volume, although rather too technical for the general reader, gives to the student in a convenient form a *résumé* of the early and of the most recent researches on fermentation (alcoholic, lactic, butyric, etc.), and is a valuable addition to the International Scientific Series, of which it is the third volume on chemical subjects. The aim and plan of the International Scientific Series has already been alluded to in this Journal (vol. v, p. 241, 1875). It is not our purpose in the present instance to criticize the subject matter of the volume before us, but to call attention to some of the shortcomings of the English version.

The most serious error is, perhaps, the translation of "*matières hydrocarbonées*" by "hydrocarbons." On page 65 and following, and throughout the book sugar, cellulose and starch are spoken of as "hydrocarbons!" A mistake scarcely less serious occurs in the description of Schützenberger's process for determining dissolved oxygen (pages 108 and following). Here Schützenberger's "hydrosulphurous acid" and "hydrosulphite" are rendered, very properly, "hyposulphurous" and "hyposulphite," but no note or comment (except the symbol) tells us that the sodium hyposulphite thus indicated is not the common "hyposulphite of soda" which still in the arts and indeed generally bears the old name. On other pages hyposulphite is used in its former sense (instead of "thiosulphate" or other name). It would therefore seem that the mistake arose from ignorance or carelessness on the part of the translator.

Among other less important blunders it may be said that "*poudre de zinc*" is not "powdered zinc" but zinc dust (zinc-staub); Sterry Hunt regarded the albuminoids as "nitriles" not

as "nitrites" (and as this mistake occurs in several places it can hardly be a printer's error); "*étant ramenée*" (page iii) should be rendered "reduced" and not "brought back," as it is a question of converting a cupric to a cuprous compound for the first time.

In a prefatory note the translator deliberately chooses to render "*invertir*," "*inverti*," etc. by "alter," "altered," etc., instead of the much more familiar "invert," "inverted," etc. It is probably also to the choice of the translator that we owe the terms "potass," "hydratation," "dishydratation," "magnesium subcarbonate," and "marine salt."

We may pass over various misprints, mentioning one only, by which a paragraph headed in the original "*Gaz Lumière*" appears with the heading "Gas-light" to the confusion of the reader. We may, however, criticize the constant use of the French words, with accents, to indicate the weights and measures of the metric system, and also the giving in every case the equivalent in English weights and measures (often to the third place of decimals) even where an approximate or relative number is mentioned. As a single instance, we read on page 111, "about 1 cub. centimètre of oxygen (·061 cub. in.) for each 10 cub. cent. (·61 cub. in.) of the solution."

It is most certainly to be hoped that the promised volumes of Wurtz, H. SteClaire Deville, and Berthelot will not suffer such treatment at the hands of translators as have Vogel and Schützenberger. As far as the reader is concerned, it is at present safer to procure the works in the original tongues; and thus one promise of the *International Series* fails to be fulfilled. W. R. N.

12. *Liquid Films.*—Dr. SONDHAUSS has extended the observations of Plateau on liquid films to the determination of the extent to which different liquids can be stretched in wire rings. He observed the lamellæ in closed vessels excluding external disturbances, measured with a balance their tension and with a manometer the pressure of bubbles on the enclosed air; he also measured the weight of such lamellæ and bubbles, whence their thickness might be inferred. With a simple contrivance consisting of a thin wire bent horizontally to an angle, and a straight wire placed across and drawn gradually away from the angle, it may be shown that all liquids may be stretched in lamellæ, and that different liquids may be compared in this respect. But Dr. Sondhauss prefers the circular wire rings, and compares (as to size) the films of forty-six different liquids. One film from a guillaja decoction, to which a little glycerine had been added, lasted over half a year.—*Nature*, xiv, 37. E. C. P.

13. *Law of Refraction.*—Prof. FOSTER, at a recent meeting of the Physical Society, exhibited and described an instrument for illustrating the law of refraction. It is founded on the well-known method of determining the direction of the ray after refraction by means of two circles described from the point of incidence as a center, the ratio of whose radii is the index of refraction. If the incident ray is projected to meet the inner circle, and through the point of intersection a vertical line be drawn, the line drawn from

the point of incidence to the point where this meets the outer circle is the direction after refraction. This principle is applied in making a self-adjusting apparatus as follows: A rod representing the incident ray is pivoted at the point of incidence, and projects to a point about four inches beyond. To its extremity is attached a vertical rod which slides through a nut in another rod also pivoted at the point of incidence. The lower extremity of the vertical rod is attached to a link, so fixed as to constrain it to remain vertical. By this means the two rods always represent respectively the incident and refracted rays, and the index of refraction can be varied by altering the position of the nut, through which the vertical rod passes, on the rod to which it is attached.—*Nature*, xiii, 535. E. C. P.

14. *Magnifying Glass.*—Mr. JOHN BROWNING has recently contrived a new form of simple magnifier which is thus described: The platyscopic lens is a triple combination, in which the chromatic and spherical aberrations are corrected by a central lens of dense glass. This lens is nearly three times as thick as the crown-glass lenses. The interior curves are almost hemispheres. The final correction for spherical aberration is made by altering the thickness of the dense glass lens. The three lenses are united by a transparent cement which has an index of refraction corresponding very nearly with that of glass. This prevents light being lost by reflection from the surface of the deep curves. The platyscopic lens is made of three powers magnifying respectively 15, 20 and 30 diameters. It possesses the convenience of the Coddington lens while its freedom from chromatic and spherical aberration renders its definition vastly superior. Its working distance is also much greater than that of any lens of equal magnifying power. This is very perceptible in the smallest of the series which gives so much space that opaque objects can be viewed with the greatest facility—an important matter to naturalists in field observations. A very good view is also obtained through water. Owing to the perfect corrections the internal diaphragm of the Coddington lens is not needed, causing a vast increase of light.—*Quart. Journ. of Sci.*, 1, 284. E. C. P.

15. *New Electro-Magnet.*—M. V. SERRIN calls attention to the difficulty experienced with powerful electric lights from the heating of the magnets in their regulators. The effect of this is to burn the insulating material and destroy the effect of the magnet by short circuiting it. This difficulty is avoided by a metallic helix with no insulating covering and so formed that the spires cannot touch. The helices are made of copper cylinders of a thickness equal to that of the bobbin. The cores are then covered with a vitreous enamel. The construction of these helices presents no especial difficulty and has the advantages of beauty and that it is easily taken to pieces. The cross-section is such that the metal is not heated perceptibly to the touch with even a powerful Bunsen battery, while it may be heated to redness without undergoing sensible change or losing its efficiency. Some further improvements have been introduced into the regulator so that the luminous point may be moved without extinguishing it, a mat-

ter of great importance in light-houses. In the model the carbons are 15mms. on a side and yet notwithstanding their large size the sensibility of the apparatus is so great that a small ring of rubber placed between the two carbons is capable of arresting the motion without undergoing a sensible change in form.—*Comptes Rendus*, lxxxii, 1054. E. C. P.

16. *Electro-magnetic Rotations.*—Mr. W. SPOTTISWOODE in a recent communication to the Royal Society discusses the phenomenon known as the rotating spark. A powerful magnet being brought near the spark the latter is seen to assume a spiral form which is right-handed or left-handed according to the direction of the current and of the magnetic polarity. The spark was passed between the poles of an electro-magnet and the effect on the form of the discharge caused by exciting the magnet was observed. For this purpose the movable poles were insulated from the main body of the magnet by interposing a sheet of ebonite thick enough to prevent the passage of the spark.

The discharge, as is well known, consists of two parts, the spark proper and a bright cloud or flame surrounding it which may be thrown to one side by a current of air. The spark is but little affected by the magnet, but the flame is at once spread out into a sheet forming a right or left handed helicoid according to the direction of the current, and following Ampère's law. Similar effects were obtained with other gases and at other pressures. The brilliancy may be increased by attaching a piece of sodium to the negative terminal, or by causing a stream of any of the volatile chlorides to flow across the field of action. The following explanation is due to Prof. Stokes. Supposing the magnetic field to be uniform, the lines of force will be straight lines from pole to pole. In such a condition everything being symmetrical, no rotation would take place. But if through any local circumstance the path of the current be distorted or displaced, then each element will be subject to two forces, one tending to turn the current around the axis, the other tending to make it follow the shortest path so as to diminish the resistance.

The general nature of the phenomenon may be described as follows: First, we have the bright spark of no sensible duration which strikes nearly in a straight line between the terminals. This opens a path for the continuous discharge which being nearly in a condition of equilibrium, though an untranslatable one, remains a short time without much change of place. Then it moves rapidly to its position of equilibrium, the surface which is its locus forming the sheet. Then it remains in its position of equilibrium during the greater part of the discharge, approaching the axis again as the discharge falls, so that its equilibrium position is not so far from the axis. Thus we see two bright curves corresponding to the two positions of approximate rest united by a less bright sheet; the first curve lies nearly in a straight line and the second nearly in a helix traced on a cylinder of which the former line is a generating line. The appearance of the discharge when viewed in a revolving mirror confirms the above remarks.—*Nature*, xiii, 698. E. C. P.

II. Geology and Mineralogy.

1. *Recent Discoveries of Extinct Animals by Professor Marsh.*—In a lecture to the Graduating Class of Yale College, delivered in the new Peabody Museum, June 3d, Professor O. C. Marsh gave a brief *résumé* of the more important results of his late paleontological researches in the Rocky Mountain region. His explorations, which were attended with much hardship and danger, have been mainly confined to the Cretaceous and Tertiary formations, and especially to their vertebrate fauna. During the past six years, the expeditions under his charge have brought to light more than 300 species of fossil vertebrates new to science, about 200 of which he has already described.

Among the extinct animals thus discovered, were many new groups, representing forms of life hitherto unknown. The most interesting of these are the Cretaceous *Odontornithes*, or Birds with teeth, which constitute a new sub-class, containing two distinct orders, viz: the *Odontolcæ*, which have the teeth in grooves, and the *Odontotormæ*, with teeth in distinct sockets. The former were swimming birds of gigantic size, with rudimentary wings, and the vertebræ as in modern birds. The type genus is *Hesperornis*, and three species are known. The second order embraces at present only small birds with powerful wings, and biconcave vertebræ. The type genus is *Ichthyornis*, and the geological horizon is upper Cretaceous. Another discovery of importance from the same formation was Pterodactyls, or flying reptiles, the first detected in this country. These are of much interest, on account of their enormous size,—some having a spread of wings of more than twenty-five feet,—but especially as they were destitute of teeth, and hence resembled recent birds. They form a new order, *Pteranodontia*, from the typical genus *Pteranodon*, six species of which are now known. With these fossils were found large numbers of Mosasauroid reptiles, and remains of more than 500 different individuals were collected. These proved to belong to two new families, *Tylosauridæ* and *Edestosauridæ*. Some of the former attained a length of sixty feet, while the latter were much shorter, the smallest being less than ten feet. These groups included several new genera and many species. This large series of specimens enabled Professor Marsh to clear up many doubtful points in the structure of these reptiles, and to determine that they possessed hind paddles, and were covered, in part at least, with bony dermal scutes. Many other Birds, Reptiles and Fishes were found in the same Cretaceous strata.

The discoveries of Professor Marsh and party in the Tertiary of the West were of no less importance. The most interesting are those made in the two Eocene lake-basins between the Rocky Mountains, and the Wahsatch Range. These basins were explored by Professor Marsh in 1870, and their Eocene age then

first determined. His explorations in this region have secured to science over 150 species of new vertebrates, most of them widely different from any hitherto known. The most remarkable of these are the gigantic mammals of the new order *Dinocerata*, the type genus of which is *Dinoceras*. These animals nearly equalled the Elephant in size, but the limbs were shorter. The skull was armed with two or more pairs of horn-cores, and with enormous canine tusks, similar to those of the walrus. The brain was proportionally smaller than in any other land mammal. Three genera and several species are known. Remains of more than 100 distinct individuals were obtained, and are now in the Yale Museum. The *Tillodontia* are another new order of mammals discovered in the same Eocene deposits. They possess many remarkable characters, which indicate affinities with the Carnivores, Rodents, and Ungulates. There are two well marked families, the *Tillotheridæ*, from the typical genus *Tillotherium*, which has Rodent-like incisors; and the *Stylinodontidæ*, in which all the teeth grew from persistent pulps. The largest of these peculiar animals was about the size of a Tapir. One of the most interesting discoveries made by Professor Marsh in the Eocene of Wyoming was the remains of Quadrumana, the first found in the strata of America. These early Primates appear to be related both to the Lemurs of the old world, and to some of the South American Monkeys. Two families are known, the *Lemuravidæ*, from *Lemuravus*, the principal genus, which has 44 teeth, and the *Limnotheridæ*, which have not more than 40. The latter group is rich in genera and species. Among the other Eocene Mammals discovered were Marsupials and Bats, not before known in a fossil state in this country. One of the most important Eocene Mammals found was a small ungulate, which is the oldest known ancestor of the horse. It was about as large as a fox, and had four toes before and three behind. The genus was named *Orohippus*, and several species were discovered. These remains, in connection with others from the later Tertiary, enabled Professor Marsh to trace the line of descent which has apparently produced the modern horse. In addition to the Eocene Mammals, many species of Birds, Serpents, Lizards, and other vertebrates were collected.

The discoveries made by the same expeditions in the Miocene and Pliocene lake-basins of the Rocky Mountains and Pacific coast were likewise very numerous, and many new forms of animal life were brought to light. One group of mammals found in the early Miocene of Oregon is allied to the modern *Rhinoceros*, but differs in having a transverse pair of horn-cores on the nasal bones. The genus was called *Diceratherium*, and one of its species is the oldest known member of the Rhinoceros family, if not its progenitor. The most remarkable mammals found in the Miocene were the huge *Brontotheridæ*, which are apparently allied both to the above group and to the Eocene *Dinocerata*. They equalled the latter in size, and had also an elevated pair of horn-cores on the maxillary bones. One genus of this family was previously known

by imperfect specimens. Besides *Brontotherium*, several other new genera of this group were found, represented by portions of over 200 individuals. With these remains was discovered a genus of small equines, *Mesohippus*, about as large as a sheep, and having three toes on each foot, with an additional "splint" bone on those in front, thus forming an interesting Miocene link in the genealogy of the horse, completed by the Pliocene genera. Over 30 species of fossil horses were collected in these formations. Among the interesting animals obtained in the Pliocene deposits were two species of large Edentates, the first Tertiary representatives of this order from America. They belong to a new genus, *Morotherium*. There were also found large numbers of Rhinoceroses, Camels, Suillines, and other mammals, as well as many Birds, Reptiles, and Fishes.

A study of the large series of extinct animals thus collected, and now in the Yale Museum, promises to throw much light on the development of life on this continent, and Professor Marsh has already drawn from them some important principles. One of these relates to the size and growth of the brain in Mammals, from the beginning of the Tertiary to the present time. The conclusions reached may be briefly stated as follows: *first*, All Tertiary mammals had small brains; *second*, there was a gradual increase in the size of the brain during this period; *third*, this increase was mainly confined to the cerebral hemispheres, or higher portion of the brain; *fourth*, in some groups, the convolutions of the brain have gradually become more complicated; *fifth*, in some, the cerebellum and olfactory lobes have even diminished in size. There is some evidence that the same general law of brain-growth holds good for Birds and Reptiles from the Cretaceous to the present time.

Some additional conclusions in regard to American Tertiary Mammals, so far as now known, are as follows: *First*, all the *Ungulata* from the Eocene and Miocene had upper and lower incisors; *second*, all Eocene and Miocene mammals had separate scaphoid and lunar bones; *third*, all mammals from these formations had separate metapodial bones.

In conclusion, Professor Marsh stated that his work in the field was now essentially completed, and that all the fossil remains collected, and in part described, were now in the Yale College Museum. In future, he should devote himself to their study and full description; and hoped at no distant day to make public the complete results.

2. *Report upon Geographical and Geological Explorations and Surveys west of the* 100*th Meridian*, in charge of Lieut. G. M. WHEELER, Corps of Engineers, U. S. Army. Published by authority of the Secretary of War.—The reports of the work done, up to the close of 1873, make six volumes: I. The Geographical Report; II. A Report on the Astronomy and Meteorology; III. On the Geology and Mineralogy; IV. On the Paleontology; V. On the Zoology; and VI. On the Botany. Besides these, there

are to be two atlases, one topographical and one geological. Volume III, and Part I of volume IV have recently been published.

Vol. III. *Geology*, 682 pp. 4to, with maps, sketches and sections. The geological reports, on portions of California, Nevada, Utah, Colorado, New Mexico and Arizona, making up this volume, are a record of good work and of valuable results. Two of the reports are by G. K. Gilbert, and one each by A. R. Marvine, E. E. Howell, J. J. Stevenson and Oscar Loew. Part of the observations and conclusions of Mr. Gilbert are brought out in an article by him, in this Journal, commenced on page 16 of this volume. They cover the subjects of orology, erosion, glacial phenomena, volcanic rocks, and the stratified rocks. All the reports, and especially Mr. Gilbert's, throw much light on the characters and dynamics of displaced and folded rocks,—a subject which the prevailing absence of soil and forest makes easy of investigation. The volume is illustrated by several fine plates of scenery along the valleys illustrating erosion, and one a case of "rain-sculpture" exemplifying admirably the origin of mountain forms.

Mr. Loew's report discusses the agricultural resources and soil of the regions examined in Colorado, New Mexico, and Arizona, gives analyses and descriptions of mineral waters and minerals, and describes the eruptive rocks.

Vol. IV. *Paleontology*, Part I. Report on the Invertebrate Fossils collected in portions of Nevada, Utah, Colorado, New Mexico and Arizona, by the expeditions of 1871–1874, by C. A. White, M.D., 220 pp. 4to, 1876.—After some general observations on the collections and the periods they represent, Professor White takes up the description of the fossils in the order of the formations, and illustrates the large number of species with twenty-one well-filled quarto plates. The fossils belong to the Primordial, Canadian and Trenton periods of the Lower Silurian; a few species to the Devonian; nearly half of all to the Carboniferous age, some of them Subcarboniferous, but the larger part of the Coal period; a few (eight) to the Jurassic period; many to the Cretaceous, and fifteen to the Tertiary. The Primordial animal fossils enumerated and described are *Acrotreta subsidua* White, *Trematis pannulus* White, *Hyolithes primordialis* Hall (?), *Agnostus intestrictus* White, *Conocoryphe Kingii* Meek, *Asaphiscus Wheeleri* Meek, *Olenellus Gilberti* Meek, *O. Howelli* Meek.—The beds of the Canadian period (Quebec Group) afforded him twelve species, among which are the Graptolite, *Phyllograptus Loringi* White, and the trilobites, *Megalaspis belemnurus* White, and *Dicellocephalus? flagricaudus* White. Four species of Graptolites are mentioned from the Trenton beds, *G. pristis?* and *G. quadrimucronatus?* of Hall, *G. ramulus* White, and *G. hypniformis* White. The Primordial fossils are from Antelope Spring, House Range, in Utah, from Pioche in Nevada, and from Ophir City, Oquirrh Range, in Utah; the Quebec fossils are from Fish Spring in House Range, and from Schellbourne and Queen Spring Hill in Schell

Creek Range in Nevada. Of Subcarboniferous species, five from a locality below Ophir City, are identical with Mississippi Valley species, of the Kinderhook group, *Strophomena rhomboidalis*, *Spirifer peculiaris*, *Sp. centronatus*, *Sp. extenuatus*, and *Terebratula Burlingtonensis*. Prof. White remarks on the similarity of the conditions in the coal-measure area over the Rocky Mountain region to those of the Subcarboniferous, and thus accounts for the close relations of the two in fossils. Of the coal-measure plants in the collection there is only a single specimen each of *Sigillaria* and *Neuropteris*, land plants being the rarest of fossils.

The descriptions of species throughout the work are well drawn up, and many points of general interest are brought out.

3. *Historical Sketch of Geological Explorations in Pennsylvania and other States;* by J. P. LESLEY, with an appendix, 200 pp. and xxvi pp. 8vo. Harrisburg, 1876.—Prof. Lesley's review of early American geological papers and explorations, constituting his chapter I, will be read with great interest. It is written with spirit and illustrates well the progress of geological ideas in the country, though laughing sometimes too heartily and inconsiderately we think over old errors incident to that progress.

Chapter II treats of the work of the short-lived "Geological Society of Pennsylvania," and "what it did to bring about the first geological survey of the State."

Chapter III gives a detailed history, geological and personal, of the first geological survey of Pennsylvania, and has special value since some of the most important principles now adopted in North American geology were then developed. In some cases, however, the views commended by the author are not those which most others would equally commend. For instance, this: "that existing mountains are the remains of a continent once standing at some easily determined higher level than the present continent;" and that this idea "has sent out of existence the old-time notions of mountains of elevation." The principle cited looks strange along side of the fact—one of many—that a large portion of the Rocky Mountain region was under salt water in the Cretaceous, and has since, some how, got up six to ten thousand feet above the sea-level. It involves an exaggerated use of one good idea at the expense of another of greater importance. But notwithstanding some such peculiarities, and the too great freedom of personal remark occasionally indulged in, American science is indebted to the author for the history.

4. *Second Annual Report of the Geological and Agricultural Survey of Texas;* by S. B. BUCKLEY, State Geologist. 96 pp. 8vo. Houston, Texas, 1876.—This report makes brief mention of some localities of the different rock-formations of the State, and treats more at length of the mineral and agricultural products. It is stated that in the valley of the Rio Grande, from six miles below Fort Quitman northward to El Paso, there are two and sometimes three terraces. The two upper consist of sand and gravel. The gravel is often filled with large water-worn quartz pebbles, and in

some places have a thickness of 100 feet or more; and for a large part of the way it is fifteen or twenty miles from the river. Veins of argentiferous galena are reported in the Organ Mountains, in El Paso County, and in the Chinati Mountain, Presidio County, (affording 16 to 76 dollars of silver to the ton); and five miles northeast of Mason in Mason County.

A mass of meteoric iron is contained in the State collections at Austin, weighing 315 pounds, which is said to have been found on the head waters of the Red River, northward of Young County.

5. *Primordial of Scandinavia.*—According to G. Linnarssen (Geol. Mag., April, 1876, p. 146, in a reply to a paper by Mr. H. Hicks), the oldest fossiliferous rocks of Scandinavia consist, in ascending order, of (1) the Eophyton sandstone; (2) the Fucoid standstone; and (3) the Paradoxides schists; and the last corresponds to the Harleck and Menevian groups of the British Lower Cambrian. The Paradoxides schists contain the Trilobite genera *Paradoxides* (*Anopolenus*, *Plutonia*), *Conocoryphe* (*Erinnys*), *Microdiscus*, *Arionellus*, *Agnostus*, and also *Leperditia*, *Hyolithus*, *Lingulella*, *Obolella*, *Orthis*, *Protospongia*, etc. The beds below the Paradoxides schists contain no trilobites. The Fucoid sandstone has afforded two species of *Lingulidæ*, and the Eophyton sandstone a number of species of *Brachiopods*, *Pteropods*, *Spongiæ*, besides the doubtful *Cruziana*, *Harlania* (*Arthrophycus*), *Eophyton*, etc. Forms like those of *Cruziana* and *Eophyton* have been found also at other horizons higher in the Silurian, and a Harlania much like the Primordial in the Rhætic beds of Scania. One of the Brachiopods of the lower beds of the Eophyton sandstone is the *Lingula* or *Obolus monilifer*, but it probably pertains to a new genus; and two other fossils are *Hyolithus lævigatus* and *Astylospongia radiata*. The thickness of the sandstone under the Paradoxides schists in Scandinavia is but a fifteenth of that of the corresponding beds in the English Cambrian; but this is no evidence that the former are younger than the latter.

The "Primordial zone" or stage C, of Bohemia is younger than the oldest fossiliferous strata of Scandinavia, and corresponds most nearly with the middle of the Paradoxides schists. That any identical species occur in both is not certain; but there are several that are closely related, as *Paradoxus Tessini* and *P. spinosus*, *Ellipsocephalus Hoffi* and *Agnostus rex*.

6. *Glacial flood.*—In a paper "on the Drift-deposits of the Northwest," in the Popular Science Monthly for July, 1873, Prof. N. H. Winchell presents the view that the terraces along the rivers and about the lakes of the Northwest [the northern part of the Continental Interior] are due solely to floods along the rivers and the lakes consequent on the melting of the great glacier. The investigations which I have made since the publication of his paper, and which are the subject of my recent memoir on Southern New England, have satisfied me that in this he is essentially right. Prof. Winchell argues, thence, against the opinion that the Champlain period was one of more or less depression of the

land over the higher latitudes of the Continent. But this conclusion does not necessarily follow, as is evinced by the facts over New England. When he says "the four-hundred-foot beach near Montreal may have had the same origin as the so-called beaches that rise several hundred feet higher in the State of Ohio," his language is ambiguous; but interpreting it by the context it is wrong, if we may trust Logan, Dawson, and others, who have studied those high St. Lawrence "beaches;" for these geologists describe them as true sea beaches and under-water marine deposits, containing *marine* shells, and some of the beds, as I know from examination, are full of such shells; and this they could not be if made by fresh water floods. The same is true of the elevated beaches on Lake Champlain, and of others on the Coast of Maine. Wherever such beaches occur they prove a depression of the land during the era of their formation; and their wide distribution leads to the natural inference that all northern New England participated in the subsidence. Such Eastern facts do not, however, *prove* that the Continental Interior, farther west, participated in the subsidence; and yet this may have been a fact. Whether so or not facts that will demonstrate the truth are difficult to find over the interior of a wide continent, and hence a uniform opinion among geologists may never be reached. J. D. D.

7. *On the Ice Age in Great Britain;* by RALPH RICHARDSON.—In this paper (Proc. Edinburgh Geol. Soc., 1876) the author gives the facts with regard to the shallow depths of ocean between Great Britain and Iceland and Greenland on one side and over the German Ocean on the other, and presents reasons for believing that there was dry land over the region in the Glacial era; that the Glaciers of Great Britain came over this emerged land from the north and west; and that the cold of the Glacial era was due in part at least to the closing thus of the Arctic, and excluding thereby the Gulf Stream. The facts appear to sustain the conclusions. The depth between Britain and Iceland mostly does not exceed 100 fathoms, and no where exceeds 1,000; and one tract of sea extending in a straight line from the eastern coast of Greenland *via* Iceland and Faroe to Scotland does not exceed 500 fathoms. The depth of the sea in the English Channel is only about 20 fathoms, and the average depth of the North Sea or German Ocean is not over 40 fathoms or 240 feet. The depth between Britain and Greenland is small compared with the average depth of the Atlantic. The author closes with the conclusion, that one of the oscillations of level, such as have often occurred over the earth's surface, had the effect to "unite Britain and Northern Europe with Greenland and the Arctic regions;" "to give the polar ice-fields access to Europe;" "to divert the course of the Gulf Steam and free Northwestern Europe from its influence; and, in conjunction probably with some diminution in the influence of the sun, to produce a Glacial epoch."

8. *Geology of Spitzbergen.*—The following facts and views on the Geology of Spitzbergen are taken from articles by Prof. Nord-

enskiöld in the January and February numbers of the Geological Magazine, edited by H. Woodward, F.R.S.—The glacial scratches in the fiords opening into Bell Sound appear to indicate that the west coast of Spitzbergen extended at least to the series of islands and rocks by which the land is now environed; and that "during the Glacial period that coast was the west coast, not merely of an island, but of a considerable Arctic continent, which toward the south was connected with Scandinavia and toward the east with Continental Siberia." These words are italicized.

No strata containing Silurian fossils have yet been found, although it is probable that the Scandinavian Silurian formation is represented by dolomitic beds, slates, and quartzyte in Mt. Hecca Hook on Treurenberg Bay. The last-mentioned quartzyte in Lomme Bay is overlaid by slates, limestone, sandstone, and conglomerates, which have afforded remains of fishes and some other undetermined fossils and are probably of the age of Upper Devonian or Lowest Carboniferous.

The rocks of the Carboniferous age include a lower and an upper Subcarboniferous limestone, and the true Carboniferous formation.

The Lower Subcarboniferous beds (called "Ursa Stage" by Heer), are best developed on Bear Island, and include therein sandstone with some slate and coal; they occur also on Ice and Bell Sounds. The eighteen Bear Island species that have been determined are *Calamites radiatus* Brgn., *Cardiopteris frondosa* Gœpp., *C. polymorpha* Gœpp., *Palæopteris Rœmeriana* Gœpp., *Sphenopteris Schimperi* Gœpp., *Lepidodendron Veltheimianum* St., *L. commutatum* Sch., *L. Carnehgyianum* H., *L. Wijkianum* H., *Lepidophyllum Rœmeri* H., *Knorria imbricata* St., *Kn. acicularis* Gœpp., *Cyclostigma Kiltorkense* Haught., *C. minutum* Haught., *Halonia tuberculosa* Brgn.? *Stigmaria ficoides* St., *Cadiocarpum punctatum* Gœpp. and Berg., *C. ursinum* H.

The Upper Subcarboniferous formation consists, beginning below, of (1) dolomite; (2) red and white sandstone; (3) Cyathophyllum limestone, containing fossil *corals*, *Brachiopods*, *Crinoidal remains*, a *Euomphalus*; (4) Spirifer limestone and gypsum, affording numerous remains of *Spirifer* and some of *Productus*; (5) Productus limestone and flint. The formation has afforded 4 species of polyp corals, 2 of Crinoids, 7 of Bryozoans, 34 of Brachiopods, 11 of Lamellibranchs, 2 of Gasteropods, 2 of Crustaceans, and 1 of Spongia. They include some species that have been supposed to be exclusively Permian, as *Camaraphoria Humbletonensis* Howse, *Productus Cancrini* Vern., *Productus Leplayi* Vern., *P. horridus* Sow., *Strophalosia lamellosa* Gein. *P. horridus* is very abundant and occurs of great size (86 mm. by 67), nearly twice as large as is known from the Permian. The beds contain also the Silurian species *Rhynchonella pleurodon* Sow., but no *Orthis*; the Russian Subcarboniferous species *Spirifer incrassatus*, *Sp. bisulcatus* var. *Sarana*, *Terebratula fusiformis*, *Productus Humboldti*, *Chonetes variolaris*; and the Carbonifer-

ous species *Euomphalus cuttilus*, *Monticulipora tumida*, *Chætetes radians*, *Cyathophyllum ibicinum*, *Syringoporæ*, etc.

The *Coal-Measures* have been distinguished on Spitzbergen only "in Robert's Valley, on the eastern side of the great bottom glacier in Recherche Bay," where the thickness is 1,000 to 2,000 feet. There is some black shale but no true coal. Species of *Sphenopteris*, *Cordaites* (*C. boracifolia* and *C. primordialis*), *Lepidodendron* are common, and some occur of *Stigmaria*, *Sphenophyllum*, *Asterophyllites*, but none of *Pecopteris* and *Neuropteris*. The same strata probably extend over Cape Ahlstrand to Van Keulen's Bay, and may occur at various other places.

The *Triassic formation* is met with in Ice Sound. The beds are principally black clay-slate with some beds of limestone and coprolitic layers. The beds have afforded remains of *Ichthyosaurus polaris* Hulke (of the size of *I. Platiodon*), *I. Nordenskiöldii* Hulke, *Acrodus Spitzbergensis* Hulke, and other vertebrates yet undetermined, besides (according to Dr. Lindström) *Ceratites Malmgrenii* Lindstr., *Halobia Lommelii* Wissm., *H. Zitteli* Linds., species of *Posidonia*, *Monotis*, etc. Some of the coprolites contain 23 per cent of phosphoric acid.

9. *The Coal Eras of India, and a Permian or Triassic Glacial period.*—Mr. H. T. Blanford, in an able paper in the Quarterly Journal of the Geological Society of London for 1875, p. 519, discusses at length the age of the coal-bearing strata of India and the evidences of a Glacial era in underlying conglomerate beds.

(1). *Coal beds and Eras.*—He arrives at the conclusion, with regard to the coal-beds, that they range from the Lower Permian to the latest Jurassic.

The beds of the Dómúdá valley, the Rájmahál hills and numerous small basins west of the Gangetic delta consist, in ascending order, of (1), The Talchir group, 800 feet; (2), the Dámúdá series (including the Barákar group (2,000 feet), the Ironstone shales (1400) and the Rániganj group (5,000), 8,400 feet; (3), the Panchét group, 1,500 feet; and (4), Coarse sandstones and conglomerates, 500 feet. The flora of the Rániganj group, includes *Glossopteris Browniana*, *Phyllotheca Indica*, *Vertebraria Indica*, besides other species of these genera, and some also of *Pecopteris*, *Cyclopteris*, *Sphenophyllum*, *Calamites*, and *Schizoneura*. The overlying Panchét group contains species of *Sphenopteris*, *Tæniopteris*, *Neuropteris* (?), *Schizoneura*, *Preissleria*; also two *Labryinthodonts* (Huxley), a *Dicynodont*, a *Thecodont*, (*Ankistrodon Indicus* Huxley), an *Estheria*, etc.

In the Rájmahál hills, beds, supposed to be equivalents of the Rániganj group, are overlaid unconformably by the Rájmahál group, which contain, besides species of the last-mentioned genera, others of *Walchia*, *Voltzia* and an abundance of *Cycads*; all are specifically distinct from those in the older groups. Besides these species, the beds contain woods of *Dadoxylon*, *Palæoxylon*, *Taxoxylon*, and of *Angiosperms* of three or four varieties, but no ani-

mal remains. In the Nagpore country and Godavery valley, the Talchir and Damuda series are recognized, the latter with *Glossopteris Browniana*, etc., and, above the latter, the Panchét group, containing remains of *Ceratodus* and *Hyperodapedon*, both Triassic genera in Europe, and the former living still in Australia. Still higher, there are beds containing Cycads. In Cutch, there are Cycads in beds—probably equivalents of the last—that are either upper Jurassic or lowest Cretaceous.

Mr. Blanford speaks of the above correspondence—which has long been recognized—between the plants of the Damuda series and those of the coal measures in eastern Australia, 5,500 miles from the Indian localities, and in the Karoo formation in Natal,—South Africa. From the facts, he makes the beds in these distant regions alike in age, and Permian. The Beaufort beds, an upper member of the Karoo series, contain remains of *Dicynodon*, *Microlophis Stowii* Huxley, *Galesaurus* and *Cynochampsa*, along with *Glossopteris Browniana*, another Glossopteris, and a Phyllotheca near *P. Indica*; and they are made by the author equivalents of the Panchét group.

(2.) *Glacial era.*—At the base of the Talchir group, (as first announced in vol. i of the Q. J. G. Soc.) there is a conglomerate consisting of blocks of all sizes, up to *forty-two feet in circumference*, imbedded in a firm silt. The bowlders, as first shown by Dr. Oldham and Mr. Feddan, in 1872, are in part scratched and polished, part like the polish of a lapidary; and the underlying Vindhyan limestone is also scratched in long parallel lines. In the South African Karoo region, there is a similar bowlder bed beneath the coal measures, in which bowlders of granite, gneiss, etc., of all diameters up to *five* or *six feet* are imbedded in a grayish blue argillaceous base, which is in some places ripple-marked. These conglomerate beds have the great thickness of 800, and in some places, 1,200 feet. Below are beds containing *Lepidodendra*, etc., which have been referred to the Carboniferous. No similar bowlder bed has been observed in Australia. Mr. Blanford regards the bowlder beds as having originated under glacial conditions, and thinks it probable that those of India and South Africa point to one and the same Glacial era. Making the lower coal-beds Permian, the Glacial era is of the early Permian; cotemporaneous with that indicated by the breccias of the British Lower Permian.

Mr. Tate, who has described, with Prof. T. Rupert Jones, the Karoo formation of South Africa, makes its age, as Mr. Blanford states, Triassic; and others have taken the same view of the coal beds (containing *Glossopteris*, etc.) of India and Australia. This view has to encounter the facts, stated by Rev. W. B. Clarke, that a coal miner's shaft sunk at Harper's Hill, New South Wales, passed through nearly horizontal beds containing *Spirifer*, *Fenestella*, *Conularia*, *Orthoceras*, etc., before reaching the conformable coal beds of the region full of *Glossopteris*, *Phyllotheca*, etc.; and also others, from Bowen River, Queensland, described by Mr. Dain-

tree, where the *Glossopteris* beds are *overlaid* by *Productus* and *Spirifer*-beds.

The paper is accompanied by a map showing the distribution of the plant beds in Eastern India, between the Ganges and the southwestern side of the Godavery River; and of others farther south, near Madras and Trichonopoly, and in the district of Cutch, where only the later beds have been observed.

10. *Graptolites.*—An article by Messrs. John Hopkinson and C. Lapworth, describing forty-five species of Graptolites from the Arenig and Llandeilo rocks of St. David's, illustrated by numerous figures on five plates, is contained in the Quarterly Journal of the Geological Society for November last. It is of special interest to the American geologist because of the many American forms which it reports from some of the British localities. In the lowest beds of the Arenig rocks, in Whitesand Bay, the species are all new; but on Ramsay Island, of nearly the same horizon, out of 16 species, 6 were first described by Hall from the Quebec group, viz: *Dendrograptus diffusus, D. divergens. D. flexuosus, Didymograptus extensus* and *D. pennatulus*, and *Trigonograptus ensiformis.* The beds also contain other species of the first two genera, and species also of *Phyllograptus, Ptilograptus, Callograptus* and *Dictyograptus* (*Dictyonema* Hall). The Middle Arenig beds of Whitesand Bay contain Hall's species, *Didymograptus patulus, Tetragraptus 4-brachiatus, Dendrograptus flexuosus, Callograptus elegans, C. Salteri*, and *Dictyograptus* (Dictyonema) *irregularis*; and the Upper Arenig of Ramsay Island, Hall's species, *Didymograptus bifidus, D. indentatus*, and *D. patulus.* No American species are among the eleven obtained from the Llandeilo formation: these eleven are of the genera *Didymograptus, Dicallograptus, Climacograptus, Diplograptus, Ptilograptus, Dendrograptus* and *Dictyograptus.*

11. *Region of eruptive rocks of the District of Schemnitz, Hungary.*—Mr. J. W. Judd, in a paper read before the Geological Society in April last, describes this Hungarian region of eruptive rocks. The rocks are andesites of the earlier upper Miocene age, rhyolytes of the later, and basalts of the Pliocene; also highly metamorphic rocks, including quartzytes, crystalline limestones, various schists, gneiss and aptyte, which are Triassic in age; and so-called syenyte, granite and greenstone. As held by Von Pettko, Richthofen, and others, the greenstones are Tertiary, they naming them greenstone-trachyte and propylyte; and, according to Judd, the granite and syenyte are only coarser forms of trachyte of the same age. The author also observes that there is complete proof that the mineral veins containing gold, silver and other metals, in Schemnitz, were formed "within the most recent geological periods, in some cases indeed, at a later date than the Pliocene."—*Nature*, No. 34.

12. *Volcanic phenomena of the Alps.*—Recent numbers of Woodward's "Geological Magazine" contain a valuable series of papers on volcanoes and volcanic phenomena, of British and European

regions, by Mr. Judd. The article in the number for May treats of the igneous ejections preceding the elevation of the Alps, which commenced in the Permian and continued through the Triassic. The best exhibitions of the erupted rocks are seen near the Lake of Lugano, on the borders of Switzerland and Italy, in the Southern Tyrol, and in the country about Raibl in Carinthia; and the author holds that they indicate that the same rocks occur beneath the Jurassic or other overlying beds throughout the Alpine region. The oldest (Permian)—the quartz-porphyry of Botzen, or a granite-like variety containing 66 to 76 p. c. of silica—covers an area of more than 1,000 square miles and constitutes mountain masses over 9,000 feet high. It is largely covered by Triassic beds of great thickness. Eruptions of the Triassic period occur in the Southern Tyrol; the rocks have the composition of melaphyre, diabase and doleryte, but are often granitic in texture, and are called monzonyte; and besides, there are tufas and volcanic ashes. Monzoni and Predazzo are noted localities, and especially because of the many minerals produced in the adjoining rocks by the erupted monzonite; among them, epidote, garnet, spinel, vesuvianite, gehlenite, mica, biotite, wollastonite, anorthite, labradorite, orthoclase, scapolite, monticellite, axinite, zircon, sphene, besides serpentine, thomsonite, chabazite, prehnite and others—a series closely related to that from the ejected masses on Somma.

13. *Reliquiæ Aquitanicæ.* Part xvii, Nov. 1875.—This number concludes the very valuable work of Lartet and Christy on the "Archæology and Palæontology of Périgord, and the adjoining Provinces of Southern France," issued under the editorial supervision of Prof. T. Rupert Jones, and published by Williams & Norgate, London. The number of quarto plates in the whole work is eighty-three, and, besides these there are many wood-cut illustrations. This last number adds to the information on the human remains of Laugerie Basse, and concludes with notes on the *Caribou* (Reindeer) of Newfoundland, and comparisons of Reindeer remains from the caverns, giving a copy of a sketch of a Reindeer on a piece of Reindeer antler from a cave in the Canton of Schaffhausen; on the *Ovibos moschatus*, a northern species at the present time, whose remains have been met with not only in the Quaternary of Great Britain, but also in the "Diluvium" of the Oise near Chauny, and at Precy, and in that of the Saal in the Gorge d'Enfer (Dordogne). The last is at present the most southern locality known; and with the remains occur those of the Cave Bear, Cave Lion, Wolf, Aurochs and Reindeer. Next follow important "Supplemental notes," containing Addenda and Corrigenda for the work.

14. *On Dalmanites dentata*; by Dr. S. T. Barrett.—Mr. J. M. Dolph of this place has recently found a nearly entire specimen of *Dalmanites dentata*, which enables me to add the following to my description of that species (p. 200 of the last volume of this Journal), and make some corrections. The thoracic segments are as described, except that all do not terminate laterally in slender

terete spines; the eight posterior segments do. Of the three anterior the first from the shield does not and the second does end obtusely, while the third has a spine about half the length of the fourth. These spines are directed outward and backward nearly at right angles to the rest of the segment, curving slightly upward near the end.

The entire specimen has an oblong-subelliptic general outline; length about equal to twice the width.

PORT JERVIS, N. Y., May.

15. *Note by Dr. Hayden, on the ore-bearing rocks of Colorado.*—In the annual report of the U. S. Geological and Geographical Survey of the Territories for 1874, on page 4, the statement is made that the "granites, schists, etc., are of probable Archæan Age, in which alone the precious metals and minerals of Colorado have been found." This statement was copied from the manuscript of Mr. Marvine, and was intended to apply only to his district, which embraced the Middle Park and the mountains about Georgetown and Central City. In the report of 1873 it was stated that ores of silver and gold occur in the Park Range, west of South Park, in limestones and quarzites of Silurian? Age, and in volcanic rocks, probably trachytic. In the Elk Mountains, galena and other silver ores occur in metamorphosed shales and quartzites of Cretaceous Age.

16. *Geology of Sumatra.*—The Geological Magazine for October and November, 1875, contains papers by R. D. M. Verbeek on the geology of Sumatra. An article on four fossil fishes, collected by Mr. Verbeek from the Lower Tertiary (or Upper Cretaceous) beds, has been published by Dr. Geinitz and Dr. V. d. Marck, in the Mitth. Königl. Min. Museum in Dresden. The article is illustrated by two plates.

17. *Report on the Geology of Wisconsin.*—This Report, prepared while the survey was under the charge of the late Dr. Lapham, is soon to be published, the Legislature of the State having appropriated $20,000 for the purpose.

18. *Geology for Students and General Readers.* Part I. *Physical Geology.* By A. H. GREEN, M.A., F.G.S. 522 pp. 12mo. London, 1876. (Daldy, Isbistin & Co.)—This volume gives a good review of Lithological and Dynamical Geology.

19. *Bulletin of the U. S. National Museum.* Department of the Interior. Published under the direction of the Smithsonian Institution. Nos. 1 and 2. 104 and 52 pp., 8vo.—No. 1. Contains three papers by E. D. COPE: (1) Check-list of N. A. Batrachia and Reptilia; (2) Check-list of the species of Batrachia and Reptilia of the Nearctic or N. American realm; (3) Geographical distribution of the Vertebrata of the Nearctic realm with especial reference to the Batrachia and Reptilia; (4) Bibliography. Mr. Cope's extensive knowledge of the species here considered and of their habits and distribution renders these chapters of great value to North American Science.

No. 2. Contributions to the Natural History of Kerguelen Is-

land made in connection with the American Transit-of-Venus Expedition, 1874–75; by J. H. KIDDER, M. D., U. S. N. I. Ornithology, edited by Dr. ELLIOT COUES, U. S. A. The collection made by Dr. Kidder contains 11 Procellaridæ, 4 Spheniscidæ, 3 Laridæ, and 1 each of the families Phalacrocoracidæ, Anatidæ, and Chionidæ. The Introduction states that the highest peak of the island, Mount Ross, is 5,000 feet in altitude and always snow-covered. Near the sea, in December, the snow-line was found on Mt. Crozier at about 2,000 feet above the sea-level. Only 27 days out of four months were without snow or rain, and a still smaller number of nights; the mean temperature for the year is near the freezing-point, varying but little from this at any time; and the island is notorious for the violence of its gales. Consequently there are no trees or shrubs, and no plant taller than a Kerguelen cabbage; and the few phænogamous plants that survive are such only as can thrive exposed to these hardships. As a natural consequence, although the island is 90 miles by 50 in area, there are no land-birds or mammals living on the island, and but a single shore-bird, *Chionis minor*.

20. *Chemisch-genetische Beobachtungen über Dolomit*, (mit besonderer Berücksichtigung der Dolomit-Vorkomnisse Südost-Tirols), von Dr. C. DŒLTER und Dr. R. HŒRNES.—This memoir contains a full review of the literature of the subject, with a discussion of the various theories which have been proposed to explain the existence of the great strata of dolomite. The results of an extended chemical examination of the dolomites of the Tyrol by Dr. Dœlter are given, embracing a considerable number of analyses. The authors reach the following conclusions, confirming in part the results of some earlier authors.

(1.) A large number of extensive strata of limestone, weakly dolomitic, have been deposited immediately through the instrumentality of organic life in the ocean.

(2.) Some minor occurrences of normal dolomite are due to subsequent metamorphosis, through the introduction of carbonate of magnesia.

(3.) The larger part of the dolomites, whether more or less rich in magnesia, have been formed from the lime secretions of sea-animals through the action of the magnesia salts contained in the sea-water (especially chloride of magnesium). Subsequent local differences have been brought about through circulating waters, dissolving out and concentrating the magnesia at different points.

E. S. D.

21. *On the Pittsburg Meteoric Iron;* by Dr. F. A. GENTH.—A chemical examination of the Pittsburg meteorite yielded the following results: Its specific gravity, which Shepard gave as 7,380 was found to be 7,741, the average of three closely corresponding determinations by Dr. Kœnig, Dr. Headden, and myself. After polishing and etching with dilute nitric acid, it presents Widmannstättian figures, which are produced by inclosed schreibersite. In the section which has been made, it happens that most

of the exceedingly minute schreibersite crystals are cut across and are seen as small dots on a frosted surface; some appear as minute needles, arranged in parallel lines, like the trees in an orchard. A few elongated patches of a whiter iron-nickel alloy are also visible.

The analysis of a somewhat oxydized piece, gave the following composition:

Iron	92·809
Copper	0·034
Cobalt	0·395
Nickel	4·665
Manganese	0·141
Sulphur	0·037
Phosphorus	0·251
	98·332

0·251 per cent of phosphorus is equal to about 1·8 per cent of schreibersite.—*From the Report of the Geological Survey of Pennsylvania for* 1875.

III. Botany and Zoology.

1. *Tree-planting, Prizes for Arboriculture.*—Prof. C. S. Sargent, the Director of the Botanic Garden and Arnold Arboretum of Harvard University, published two or three months ago, *A Few Suggestions on Tree-planting*, in the Massachusetts Board of Agriculture's Report for 1875, and an edition was separately issued. The economical importance of re-foresting poor or agriculturally worthless lands in that State, and elsewhere, was strongly stated and judiciously enforced by plans and estimates, and the proper trees for planting on a large scale indicated. Another board, namely the Trustees of the Massachusetts Society for Promoting Agriculture, having some trust-funds at disposal, has now come forward, reprinted Prof. Sargent's pamphlet for gratuitous distribution, adding particular directions for the planting and management of seedling trees, and offering very handsome prizes for special plantations within the State of Massachusetts. This board offers, in the first place, for the best plantation of not less than five acres of larch, or on the cape, &c., of Scotch or Corsican pine, originally of not less than 2700 trees to the acre, on poor, worn-out or otherwise agriculturally worthless land, a prize of $1000. For the next best, a prize of $600; for the third best, $400. Next, for the best plantation of the same extent with American white ash, not less than 5000 trees to the acre, a prize of $600; for the next best, $400. Intending competitors must notify the Secretary of the Society, E. N. Perkins, Jamaica Plain, Boston, as early as Dec. 1, 1876, and plant in the spring of 1877. Special directions, not only for planting and caring for, but also for procuring trees for the purpose, are given in the pamphlet, and a citizen of Boston patriotically offers to look after the importation

of the seedling trees, which in such quantities and for next year's planting would have to be obtained mainly in Europe, at least the pines and larches. The ashes, probably, would have to be raised from seed; and the time, if need be, would doubtless be extended. The prizes to be awarded in the summer of 1877. Mr. Sargent's estimates promise a handsome return for the capital and labor invested in judicious tree-planting for economical purposes; these timely prizes may stimulate enterprise; and the sense of contributing to the adornment as well as to the material resources of the country should also be a motive and a reward. A. G.

2. *Heteromorphism in Epigæa.*—The May-flower, being more largely gathered and brought under our notice than any other wild blossom—at least in the Atlantic States—should be well known in all the details of structure. But it hardly is so. The structure of its stigma was first well described in the 5th edition of my Manual of the Botany of the Northern United States, and the likeness to *Pyrola* suggested. I suppose that this likeness is really one of relationship, but not of a near degree, as most other points of similarity are wanting. From the difference in the stigmas of different flowers, I was disposed to think that the five lobes lengthened and protruded with age, in the manner of *Pyrola;* but this does not prove to be the case. In all cases, however, the apex of the style is as it were hollowed out or extended into a ring, with a 5-crenate border, to the inner face of which the five stigmas are adnate, each before one of the small teeth or lobes, and extending sometimes slightly beyond it, but remaining short and erect, sometimes much beyond and radiately expanded.

In Michaux's Flora is the note "Flores omnes in nonnullis individuis abortivi," and botanists are generally aware that fruit is seldom met with. The flowers have been said to be unisexual (diœcious); but all appear to have well formed ovary and ovules, although some individuals were known to want the stamens. Professor Goodale, knowing a station in Maine in which *Epigæa* year after year sets fruit, kindly procured from thence a large number of fresh specimens; and these I have now examined in regard to stamens and pistil. They show the following heteromorphous condition of things.

(1.) About ten per cent of the specimens have a style considerably longer than the stamens, raising the stigmas a little out of the throat of the corolla, in which the anthers are included: the stigmas are cylindraceous, radiate like the spokes of a wheel, half a line in length, therefore strongly projecting, moist and glutinous, and evidently in good condition for fertilization. The anthers in these flowers are slender, commonly withering without dehiscence, and containing few yet perhaps well-formed pollen-grains. The fruiting specimens gathered at the same station in former years all evidently belong to this form, as the persistent style and long stigmas show. One or two specimens of this form manifest a disposition to convert their anthers into petals; but this is occasionally seen in other forms.

(2.) A smaller number of specimens show the stigmas of the preceding on a shorter style, sometimes so short as to place the radiating stigmas as low as the middle of the tube of the corolla, sometimes bringing it nearly up to the throat. In one instance a short-styled flower was detected in a cluster of flowers otherwise of the character of No. 1. These short-styled blossoms, instead of having more conspicuous or higher anthers than in the long-styled, bear them either at the same proportional height and in the same condition, or bear mere rudiments of anthers, or not rarely none at all, and even the filaments are smaller, abortive, or occasionally altogether wanting. This sometimes happens in No. 1 also.

(3.) The larger number of flowers, perhaps three-fourths of the specimens under examination, have the long style of No. 1, an ovary equally well-formed and ovuliferous, but either rather smaller or not going on to grow; but the stigmas are short, only slightly projecting beyond the lobes of the cup to which they adhere, in all stages erect, and comparatively smooth and dry. Their tips, however, appear somewhat papillose under a strong lens, and grains of pollen placed thereon incline slightly to adhere, yet not so much as upon the surface of the style far below, which gets well covered with pollen from the contiguous anthers. The difference between these stigmas and those of the foregoing forms is striking and constant, no gradations between them having been detected. The anthers abound with pollen, and are dehiscent at or a little before the opening of the corolla.

(4.) A considerable number of such flowers have a shorter style, so that the stigma stands as low as the base of the five longer anthers, in one or two even lower than all the anthers, otherwise all is as in No. 3, of which this seems to be a mere variation. And here also, although not very definitely, there is a tendency to having lower instead of higher anthers in connection with the short style.

The flowers of *Epigæa* may therefore be classified into two kinds, each with two modifications; the two main kinds characterized by the nature and perfection of the stigma, along with more or less abortion of the stamens; their modifications, by the length of the style. The first is leading to dioicism, the second points to dimorphism. I am not aware that either unisexual or dimorphous flowers are otherwise known in the *Ericaceæ*. Dimorphism (as exemplified in Primroses, *Houstonia*, and *Mitchella*) may be regarded as the more perfect arrangement on the score of economy, as it secures cross-fertilization along with fertility of all the flowers. It would seem as if this had been attempted in *Epigæa*, but that the stamens did not respond with the requisite correlation to the long and short styles; and the same may be said of certain flowers in one or two other families. Of dichogamy, the other equally economical method, I find no indication in *Epigæa* blossoms. But they appear to be now falling back upon the remaining, less economical mode of securing the end, namely, by unisexual blossoms.

It would be interesting to know whether the small-stigma

forms of *Epigæa* are ever fruitful, or fully so. It might not be difficult to ascertain the kind of flower in any case which has matured fruit; for the style and stigmas persist until the capsule is well formed in the fruit thus far known.

The æstivation of the corolla is that of the tribe, imbricated, but with a strong tendency to convolute; more commonly there is only one exterior and one interior lobe. A. G.

3. *Essay on the Immigration of the Norwegian Flora during alternating Rainy and Dry Periods*, (with a colored map of Norway); by AXEL BLYTT. Christiania. pp. 87, 8vo. 1876.—This is the substance of two lectures delivered by Dr. Blytt at meetings of the Christiana Natural History Society, in January and in October, 1875. Dr. Blytt's father was the most accomplished botanist of Norway, and the son takes naturally and lovingly to the same pursuits. Following the example set by Dr. Thorel and other Scandinavian naturalists, and which is to us pleasant and convenient, Dr. Blytt publishes this essay in the English language, which he writes correctly and with apparent ease.

There are, so to say, two floras in Norway; one, which may be termed the insular, belongs to the coast or western part of the country, to which the Gulf-stream has given an insular character of climate; the other, the continental or boreal. There are, besides, the generally diffused species, which are indifferent to the variations of climate. The rare continental species prefer a dry and loose substratum; the insular, a solid or moist soil; and there are remarkable leaps in the extension of both the continental and insular species. To explain these leaps is to bring in the question of the migration of plants. "Do plants migrate all at once across large tracts, or do they extend themselves little by little and by short distances at a time?" Although drifting ice, bringing seeds and plants lodged in earth, is a known means of transport, yet "everything indicates that conveyance to small distances is the rule." The case of the Norwegian flora "becomes easily intelligible if we assume that our climate since the ice-period has undergone secular alterations; that it has been at certain times more insular, and at others more continental; when a dry period is succeeded by a moist period the continental species must become rarer; when a moist period is followed by a dry time the plants which love moisture will be scarcer. Thus the great leaps in the distribution of species seem to point to a more continuous extension in ancient times." The study of peat-bogs resting on the site of extinct forests, and these of different ages and character, furnishes evidence of these perturbations of climate, extending through long and remote periods. "During such alternating periods," wholly prehistoric, "the country seems therefore to have received its present vegetation. We see it first covered with inland ice, which projected out into the sea and dispersed Scandinavian migratory blocks over the plains of Central Europe. When the ice, during a drier period, retired from the shore, a flora immigrated resembling that which now adorns the

wastes of Spitzbergen, North Greenland, and Melville Island,—small, hardy, and tuft-forming plants, which often display an unexpected splendor of flowers with the purest and deepest colors. Then came the gray osiers, juniper and birch, cherry-ash and rowan, with a host of new immigrants. The moisture increased, peat began to grow, and the arctic flora to recede. But the climate became warmer; the ice melted more and more; elm and hazel, lime, ash and maple, and other tender foliferous trees came, with a number of species that grow in their company. At that time the climate was dry. But when the land rose further a new revolution came about. A great rainy period buried the foliferous forests in peat; then came fox-glove (*Digitalis*), holly (*Ilex*), and the other species which we now find, especially in the rainy regions of the west coast. A new dry period followed, and pine forest grew on the bogs. Again came a rainy period. The pine forests were buried in peat. And during these last changes in our climate there came, probably, that part of our flora which is peculiar to our lowest southernmost regions."

"Our flora has acquired a uniform stamp, because some few species, which were insensible to the changes of climate, have little by little conquered a place which there is now no cause for giving up. But, here and there, on the friable slates in the mountain districts, on the moist mountain slopes and in the forest valleys, as also on wild rubble-slopes, under steep walls of rock, on the heather-tracts of the west coast, on the slate rocks in the Christiania fiord, on the cliffs of the coast in the province of Christianssand, on the gravel and sand of the edge of the shores, we find remains from these days gone by, remains which relate how our country received, little by little, the vegetation that now clothes our mountains and valleys."

With few and doubtful exceptions all the plants of Norway are also found beyond the borders of the country; there are peculiar forms, but none distinct enough from its congeners to be unequivocally recognized as a distinct species. Such forms, as Prof. Blytt remarks, are what would be expected under the vicissitudes which he refers to. A species with an unbroken and continuous hold and full occupation of a region has little chance for fixing variations. But forms reduced to isolation by stress of circumstances, having no opportunity to cross with their brethren, will preserve and have the best opportunity to develope their individual peculiarities, fix them into a race or subspecies, and when a turn of the climate favors them may multiply and occupy the district with a race markedly different from the common type of the species elsewhere. A. G.

4. *Genera Plantarum*, . . . *auctoribus* G. Bentham et J. D. Hooker. Vol. secundum, sistens Dicotyledonum Gamopetalarum Ordines XLV, Caprifoliaceas—Plantagineas. Londoni, 1873–1876.—This is the title page, somewhat shortened, of the second volume of this noble work, of which the first part, 533 pages, was issued in the spring of 1873, and the second—bringing the volume

up to 1279 pages, and the subject to the end of the *Gamopetalæ*, followed by some corrections and a good index—is now happily before us. Our scattered botanists will be glad to know this; also that the third and final volume, according to present prospects, will not be long delayed. Considering the extent and formidable character of this undertaking, and the large amount of other work which both authors have upon their hands, the rate of progress thus far is remarkable. The work has the names of two well-known London publishers upon the title page, Reeve & Co., and Williams and Norgate, and can be had through the ordinary channels of the trade. If any of our botanists who desire to order it have any difficulty in the way of procuring it through the booksellers, they are at liberty to communicate with the writer of this announcement. A. G.

5. *Botany of California.* Vol. I. *Polypetalæ*, by W. H. Brewer and Sereno Watson. *Gamopetalæ*, by Asa Gray. 1876. —This long-expected volume has at length made its appearance. It fills 628 pages, besides the 25 pages of prefatory matter, and is uniform with the publications of the Geological Survey of the State of California, of which it was intended to form a part, and may still do so, if the State soon takes it up. There is no necessity of appending to this announcement a history of this work. Suffice it to say that the present volume—the larger part of the projected work—is now brought out and placed within the reach of botanists and those interested in the results of botanical investigations, by the indomitable perseverance and energy of the State Geologist, Prof. Whitney, and by the considerate liberality of the following gentlemen, citizens of California, who furnished the means for carrying it on after the State abandoned it, viz: *Leland Stanford, D. O. Mills, Lloyd Tevis, J. C. Flood, Charles McLaughlin, R. B. Woodward, William Norris, John O. Earl, Henry Pierce, Oliver Eldredge, S. Clinton Hastings.* The scientific gentlemen engaged have done their part, and those who have done the State's duty in the premises are understood to be ready to supply the necessary means for carrying the second and concluding volume through the press. When this is done it may be said that no other State in the Union has such a well-ordered and complete Flora.

The Introduction, by Prof. Whitney, giving some account of the undertaking, fills three pages. A note supplies some special explanation of the plan of the work; the remainder of the Preface is occupied by two keys to the Natural Orders herein comprised; first, an analytical artificial key; second, a synoptical key, giving the orders in their sequence, or nearly so, and with reference to exceptional cases and anomalies. The two may supplement each other, and greatly assist the ordinary student or amateur botanist, who cannot be expected to have the characters of the orders well in hand, nor to recognize aberrant members at the first glance. Such keys are very useful, almost indispensable; but it is impossible to make them perfect so as to provide for every case. They

should be used as helps, not as an absolute reliance or as a mechanical substitute for brains.

The *Polypetalæ* occupy 276 pages; the *Gamopetalæ*, 346. Without reference to the scientific merits of this work—of which others will judge—we are free to pronounce its plan and its typography as unsurpassedly excellent. A. G.

6. *Quarterly Bulletin of the Nuttall Ornithological Club, Cambridge, Mass.*, vol. I, No. 1, April, 1876. 28 pp. 8vo, with one beautifully colored plate.—The annual subscription for this valuable publication is only one dollar, or 30 cents per number. It is to be issued quarterly in numbers of 16 pages.

IV. Astronomy.

1. *Astronomical Tables, comprising logarithms from* 3 *to* 100 *places;* by Henry M. Parkhurst. New York, 1876.—We have received a copy of these tables, now issued by the author though his plan for the whole work is still but partially worked out. The first part of the book of 224 pages contains about 70 tables. Elaborate tables are given to aid in computing logarithms to a large number of decimals, to 8, 10, 15, 20, 30, 60, and even 100 places, by a method which the author claims as new. Ordinary four-figure tables of logarithms, addition and subtraction logarithms, log. sines, tangents, &c. Numerical tables, as primes, least divisors, reciprocals, multiples, squares, &c., follow, which with the logarithms make about three-fourths of the tables. The remainder consists of about 40 astronomical tables of various kinds. In Parts 2d and 3d are explanations of the use and the theory of the tables. They are full of interesting and valuable suggestions and information from the author's experience as an amateur observer. They also contain large numbers of formulas for astronomical computation. To many the use of phonetic print will be repulsive, but we wish success to any effort to simplify the spelling of English words. The author's occupation as a stenographer has led him to condense the tables and use abbreviations at the expense, in some cases, of clearness. He has certainly succeeded in putting into a moderate size a large variety of useful matter.

V. Miscellaneous Scientific Intelligence.

1. *Probability of error in writing a series of numbers.* Letter to the editors, dated St. Louis, May 10, 1876.—Not long since while writing logarithms that were being read to me, I observed that the probability of error in writing the numbers appeared to be much less at the extremities of the number, than in the middle. This has been investigated quite at length with numbers of from five to ten digits. It is found that the probability of error is in all cases expressed by the terms of the expanded binomial

$$(a+b)^n$$

where n is a function of the number of digits. Thus far a and b

have always been unequal, with all the persons yet experimented upon. The probability of error is greatest just after the middle of the number.

This has led to an interesting investigation on the power of memory. Allowing definite intervals (t) of time to elapse between the giving and the writing of the number, and it is evident that the number of errors will increase with the value of t.

In order to aid the experimenter in abstaining from mentally repeating the number which he is to write, he is allowed to determine the value of (t) by counting the beats of a seconds pendulum. The investigation is yet in progress, but enough has been done to develop the fact that the relation between the number of figures (per 100) written correctly, and the values t, is a logarithmic one. It is the same as the function expressing the decrease in the amplitude of the beats of a pendulum, in time, as due to a resisting medium. F. E. NIPHER.

2. *Record of Science and Industry for* 1875; edited by SPENCER F. BAIRD. 646 pp. 8vo. New York, 1876. (Harper & Brothers.)—Professor Baird's scientific annual for 1875 has recently been issued. It is a work not only for men of science, but also for all who would inform themselves as to the new facts and discoveries in science and the practical arts, and learn something of the world's progress in knowledge.

3. *Transactions of the Connecticut Academy*, vol. III, part I. —This volume contains: I. A report on the dredging in the region of St. George's Banks in 1872, by S. I. Smith and O. Harger, with 8 plates; II. Descriptions of new Hydroids by S. F. Clark, with 2 plates; III. On the Chondrodite of Brewster, N. Y., by E. S. Dana, with 3 plates—the paper which was condensed for volume ix of this Journal; IV. On the Transcendental Curves $\sin y \sin my = a \sin x \sin nx + b$, by H. A. Newton and A. W. Phillips, with 44 plates, containing photo-lithographic transfers of 148 different examples of the curves; V. On the equilibrium of Heterogeneous Substances, First Part, by J. Willard Gibbs, a profound paper, occupying 150 pages, putting new methods of analysis in the hands of mathematicians and physicists.

Notes of the following works are unavoidably deferred:

Bulletin of the U. S. Geological Survey of the Territories. Vol. II, No. 3.

Geographical Distribution of Plants. Part II. Plants in their wild state; by Charles Pickering, M.D., author of The Races of Men. 524 pp. 4to. 1876.

Report on the Geology of the Eastern portion of the Uinta Mountain, and a region of Country adjacent thereto; by J. W. Powell. 218 pp. 4to, with an atlas. Washington. Department of the Interior. 1876.

Geological and Natural History Survey of Minnesota. Fourth Annual Report, for 1875; by N. H. Winchell, State Geologist. 80 pp. 8vo. St. Paul, 1876.

Report on the Invertebrate Cretaceous and Tertiary Fossils of the Upper Missouri Region. 630 pp. 4to, with 45 plates. 1876. Vol. ix of the Quarto Series of the U. S. Geol. Survey of the Territories in charge of Dr. F. V. Hayden. Department of the Interior.

OBITUARY.

ANGELIN, the eminent Swedish Paleontologist, died at Stockholm on the 13th of February, aged seventy years.

E. BILLINGS, the able Paleontologist of the Canadian Geological Survey, has recently died.

APPENDIX.

ART. IX.—*On a new Crinoid from the Cretaceous formation of the West;* by GEORGE BIRD GRINNELL. With Plate IV.

AMONG the many interesting fossils recently received from the West by the Yale College Museum, is a new Crinoid from the Cretaceous of the Uinta Mountains and of Kansas. No crinoids from the American Cretaceous have hitherto been described, and for the discovery of this species we are indebted to Prof. O. C. Marsh, who has done so much to bring to light the geological treasures of the West.

The Crinoid in question belongs to the group *Astylidæ*, or free Crinoids, and, as suggested by Prof. Marsh in his earliest paper on the Geology of the Uinta Mountains,* is allied to the genus *Marsupites* of Miller. From that genus, however, it differs widely in the number and arrangement of its plates, in having apparently ten arms, and in other characters; and it is possible that an examination of additional material may show it to be the type of an entirely new group. This point, however, cannot at present be determined.

Uintacrinus socialis, gen. et sp. nov.

The body as seen is somewhat discoidal in form, owing to pressure, but in life was evidently subglobose. The basal and subradial plates are imperfectly known. In the most perfect specimen, (figure 1,) three radial plates are found, irregularly pentagonal, hexagonal, or heptagonal in form, and varying considerably in size. Of these, the third or superior seems to be always the largest and most regular in outline. It is heptagonal, and two of its longest sides slope downward from the superior angle. The second radial is about equal in size to the first. All are wider than high. The third radial bears on each of its superior sloping sides in immediate succession five secondary radials, irregularly pentagonal or hexagonal in shape, and all wider than high. The fifth of these approaches in shape the proximal armpiece, to which it gives immediate support.

The arm pieces are thin, and horizontally compressed from without inward, their shape being sub-elliptical. The arms give support to delicate pinnulæ, or tentacles, for a portion of their

* This Journal, vol. i, p. 191, March, 1871.

length, though at what point these first appear is as yet uncertain. The more distant arm pieces show, when the articular surfaces can be examined, a distinct radiate structure, and there are traces, in some of the pieces which are exposed, of a canal, which in life may have given passage to the "axial cord" (nerve) of Dr. Carpenter. There is also to be seen on the inner side of several of the more distant arm pieces a deep depression, the radial furrow, which gives to the plates a subcrescentoid shape. These characters cannot be well made out, as all the pieces which show them are badly weathered. The arm pieces diminish very gradually in size, and the arms are long. On one of the slabs they have been traced continuously for a distance of eight inches with but little change in size, and it seems probable that in life the spread of the outstretched arms may have been two feet or more.

The interradial arms are irregular in shape, somewhat contracted near the middle, becoming wider above and below. They consist of about sixteen large irregular plates varying widely in size, and of from sixteen to twenty smaller ones, placed high up between the arms, and in part concealed by them. The former range from pentagonal to octagonal in shape, and although the specimens are not sufficiently perfect to enable the arrangement to be determined with certainty, it seems to be as follows: commencing below, opposite the first radial is a single plate; next above, in line with the second radial are two; and then three opposite the third. Succeeding these, and lying between the first of the secondary radials, is a single wide octagonal plate, and above this eight others, somewhat irregular, extending up in pairs to between the fifth secondary radials (figure 1). Immediately above these eight follow the smaller plates, four or six in a horizontal series, diminishing rapidly in size, and soon disappearing beneath the arms. A very small quadrangular plate is inserted between the first and second radials and the interradial plates which are opposite these. It is not certain, however, that this arrangement is altogether constant. In fact the other side of the specimen from which this is taken, though too imperfect for use, suggests a larger interradial arm, and hence, a probable difference in the number of the plates.

The interaxillary areas consist of about ten large plates and from sixteen to twenty smaller ones, the latter arranged much as in the interradial arm. Of the larger ones, several of the lowermost are much weathered, and their shape and arrangement cannot be positively ascertained from the specimens at hand. The inferior plate is the largest. It is higher than wide, octagonal, and somewhat shield-shaped, apparently supporting, on its superior sloping sides two high and rather narrow pieces, which in turn, give support to two small subtriangular plates.

Above these are four others in pairs, and these are followed by the smaller ones in fours, becoming rapidly less in size, as in the interradial arm.

The specimens are found in a soft light-colored limestone, and a considerable mass of the rock is often made up of their remains, as shown in the accompanying plate, figure 2, indicating that the individuals of this species lived together in large numbers. To this fact the specific name refers. It is needless to remark at length on the great interest which attaches to this species, the first crinoid known from the Cretaceous of the new world. The fact that it lacks a stem, thus resembling the genus *Marsupites* from the English chalk, suggests the advance made by some of the Crinoids that survived until the Cretaceous, over the older forms that lived in Paleozoic time.

The first specimen of the species here described was discovered by Prof. Marsh in the Cretaceous of the Uinta mountains during the autumn of 1870. It was found associated with the scales of a *Beryx*, and *Ostrea congesta* Con., typical Cretaceous forms. The species is apparently rare in this locality, as a diligent search by the writer and other members of the expedition failed to bring to light any more specimens. Others have since been received from the Cretaceous of Kansas, where they were associated with the Odontornithes, Pterodactyls and Mosasauroid reptiles of that formation.

The writer is under many obligations to Prof. Marsh for the opportunity of examining these specimens, and for most valuable suggestions in regard to the literature of the subject.

YALE COLLEGE, New Haven, June, 1876.

EXPLANATION OF PLATE.

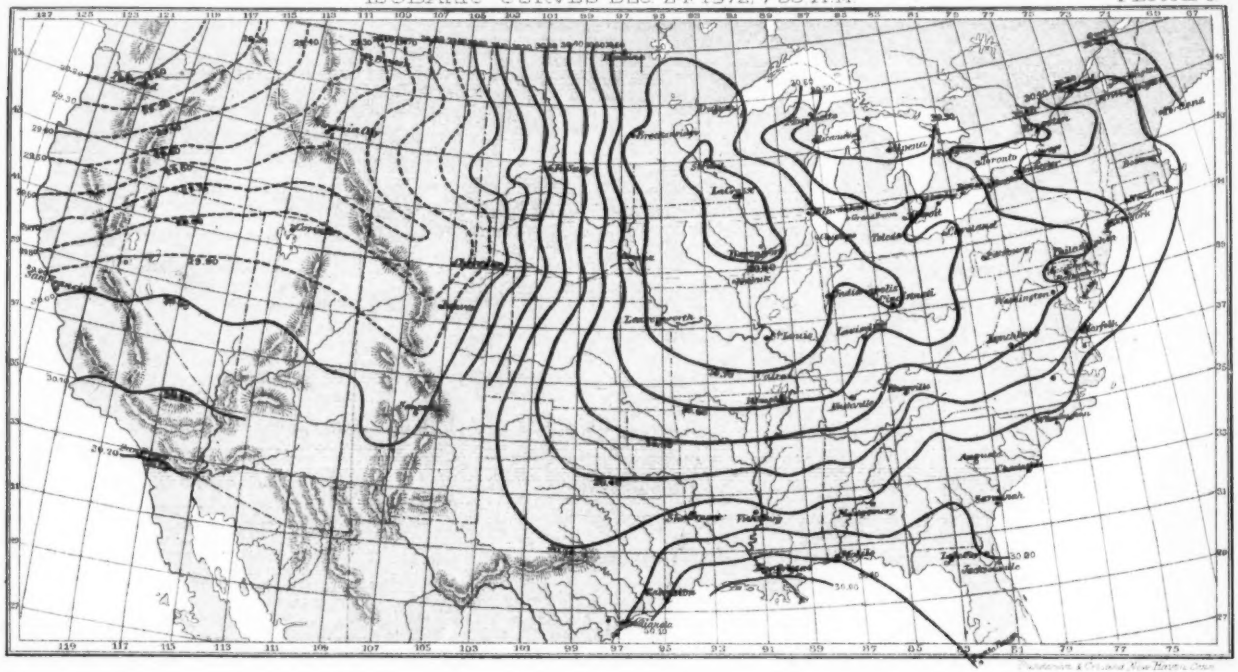
Figure 1. *Uintacrinus socialis.* Side view of a specimen showing radials and interradial arm. Natural size.

Figure 2. *Uintacrinus socialis.* Side view of a weathered specimen showing radials, interaxillary area, arms and pinnulæ.

a and *b*. Two of the more distant arm pieces magnified, showing the radial furrow, and indistinctly, the grooves radiating from the center.

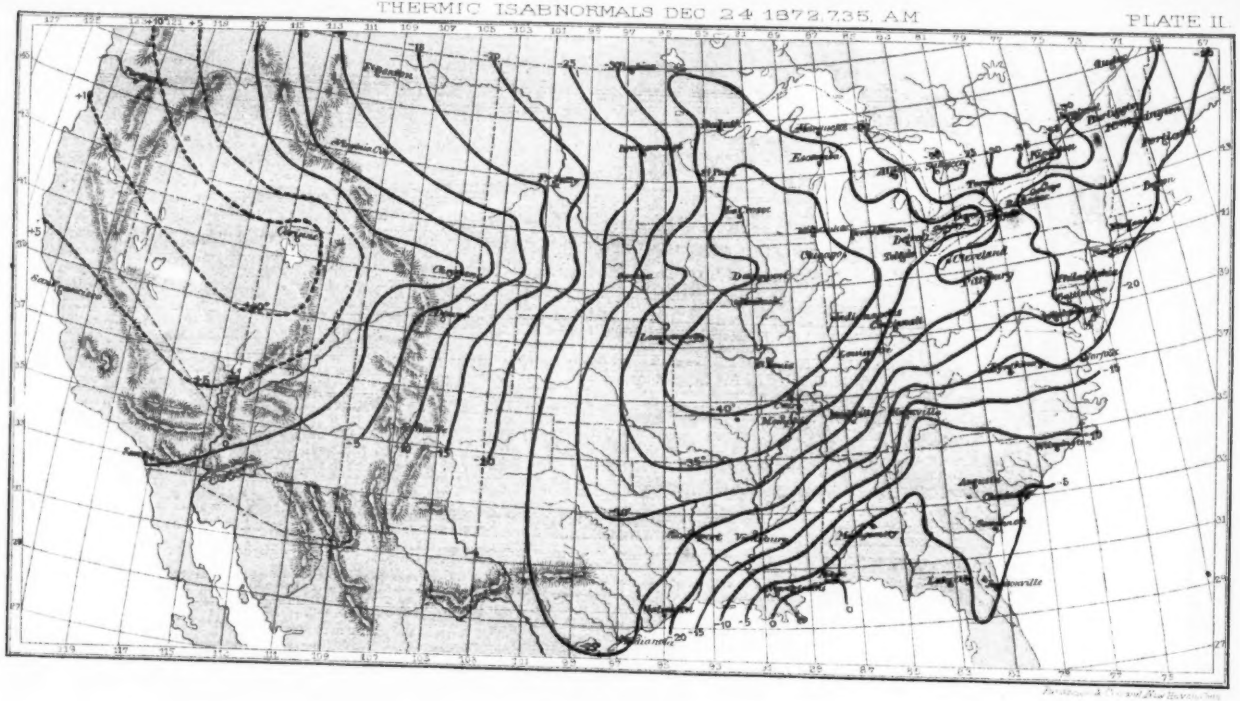
ISOBARIC CURVES DEC 24 1872, 7 35 A.M

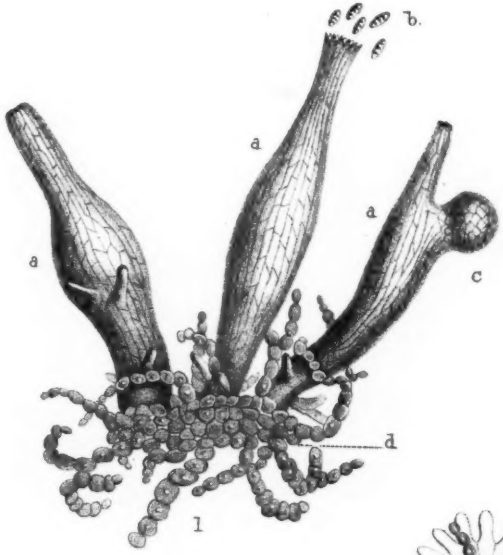
PLATE 1

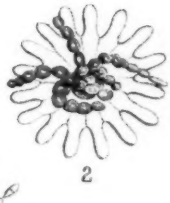


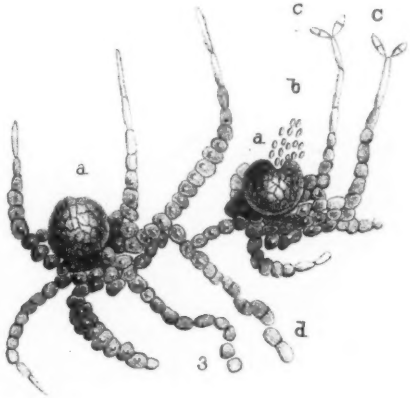
THERMIC ISABNORMALS DEC 24 1872 7.35 A.M.

PLATE II.









T. Sinclair Sc. & en. lith. Phila.

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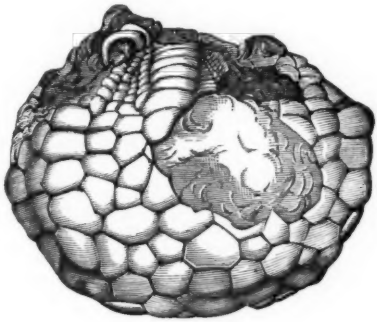

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×2.

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×3.

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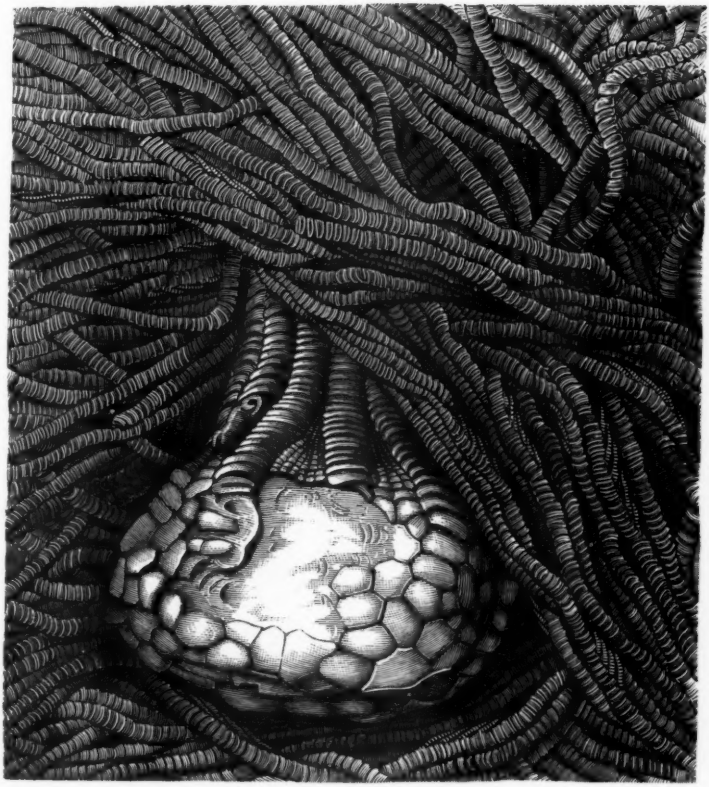

UINTACRINUS SOCIALIS. Grinnell.